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THE OBJECTIVE OF THE INTERIM RESPONSE ACTION IS TO IDENTIFY, LOCATE, AND CLOSE AT LEAST 350 ABANDONED WELLS ON RMA IN ORDER TO PREVENT MIGRATION OF GROUND WATER BETWEEN AQUIFERS. THE SCOPE OF WORK INCLUDES:

1. COMPILATION OF A WELL INVENTORY AND DATABASE
2. FIELD LOCATION OF WELLS
3. CLEANING AND CLOSURE OF APPROXIMATELY 350 WELL
4. DOCUMENTATION OF CLOSURE ACTIVITIES.

SECTIONS OF THIS TASK PLAN DETAIL INFORMATION ON:

1. ABANDONED WELL IDENTIFICATION AND LOCATION
2. WELL CLOSURE PROCEDURES
3. ARAR'S
4. CHEMICAL ANALYSIS PLAN
5. QUALITY ASSURANCE PROGRAM
6. DATA MANAGEMENT

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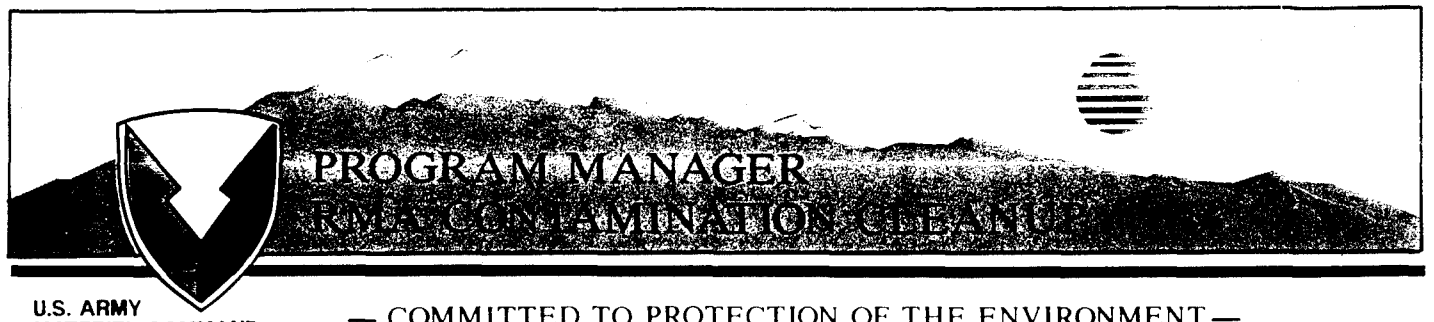

U.S. ARMY
MATERIEL COMMAND

— COMMITTED TO PROTECTION OF THE ENVIRONMENT —

FINAL
TASK PLAN
RMA ABANDONED WELL CLOSURE PROGRAM
VERSION 3.0

May 1989
Contract No. DAAA 15-88-R-0023

ROY F. WESTON, INC.
215 Union Boulevard, Suite 600
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REQUESTS FOR COPIES OF THIS DOCUMENT SHOULD BE REFERRED TO THE PROGRAM MANAGER FOR THE ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP, AMXRM ABERDEEN PROVING GROUND, MARYLAND.

89192R04

LITIGATION TECHNICAL SUPPORT AND SERVICES
ROCKY MOUNTAIN ARSENAL

FINAL
TASK PLAN
RMA ABANDONED WELL CLOSURE PROGRAM
VERSION 3.0

May 1989
Contract No. DAAA 15-88-R-0023

Prepared for:

U.S. Army Program Manager
For Rocky Mountain Arsenal
Contamination Cleanup

Prepared by:

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SECTION 1

INTRODUCTION

1.1 DESCRIPTION OF ABANDONED WELL PROGRAM

The Rocky Mountain Arsenal (RMA) occupies over 17,000 acres (27 square miles) northeast of Denver, Colorado. RMA is immediately south of the city of Henderson, Colorado and directly east of Commerce City, Colorado in western Adams County (Figure 1-1). The Arsenal was established in 1942 and has been used for the manufacture of chemical and incendiary munitions as well as chemical munitions demilitarization. RMA leases manufactured industrial chemicals from 1947 to 1982.

During the period from 1943 to 1950, RMA distilled stocks of Levinstein mustard, demilitarized several million rounds of mustard-filled shells, and test-fired mortar rounds filled with smoke and high explosives. During this period many types of obsolete World War II ordnance were destroyed by detonation or burning.

In 1947, portions of RMA were leased to Colorado Fuel and Iron Corporation (CFI) and Julius Hyman and Company. CFI manufactured chlorinated benzenes and dichlorodiphenyltrichloroethane (DDT). Hyman produced a variety of pesticides, insecticides, and herbicides. Hyman assumed the CFI lease in 1950. In 1951, Shell Chemical Company (Shell) assumed the Hyman lease. Manufacturing by Shell ceased in 1982.

Hundreds of monitoring wells have been installed on the RMA property (both Army operated and leased portions) since 1942 (post-1942 wells). These wells vary from two to six inches in diameter and range in depth between 15 and 231 feet.

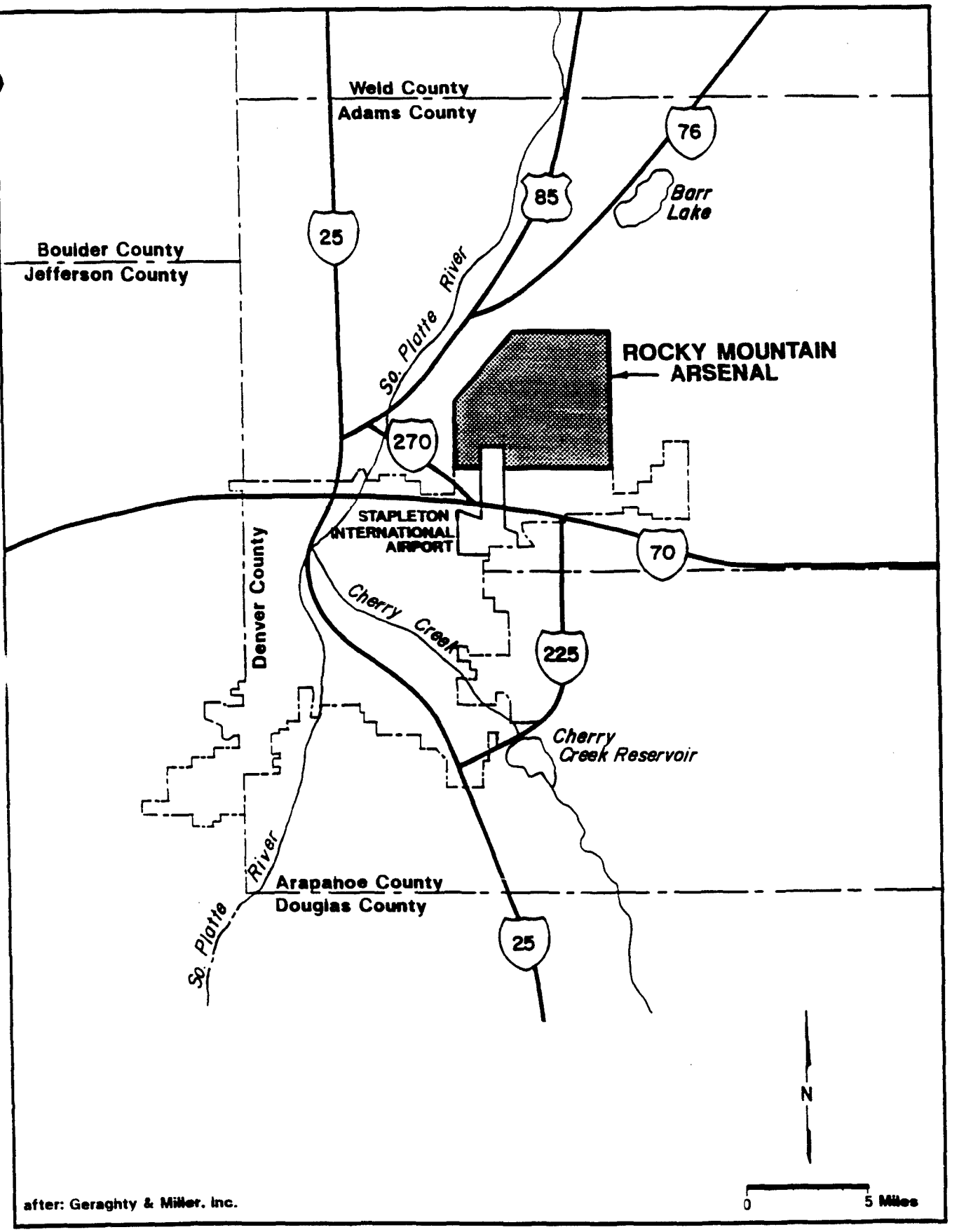


Figure 1-1: ROCKY MOUNTAIN ARSENAL LOCATION MAP

Information on these post-1942 wells has been compiled into a computer database. More information on this database is presented in Section 2.

The Program Manager's office for the RMA contamination cleanup (PMRMA) became concerned about the possibility of contaminants migrating between aquifers through unused and unknown wells on the property. This concern prompted the establishment of an Interim Response Action (IRA) task to locate, examine, and close wells which could possibly contribute to this cross-contamination of aquifers. The significant events leading up to and including the award of this task to Roy F. Weston, Inc. (WESTON) are presented below:

October 3, 1986	PMRMA issued Proposal Delivery Order to Ebasco Services, Inc. (Ebasco) under Contract Number DAAK11-84-D-0017 to locate, sample and plug abandoned wells at RMA.
April 17, 1987	PMRMA awarded Task Order 37 to Ebasco to carry out the first phase of the well closure program at RMA.
June 9, 1987	PMRMA held a meeting with Shell Chemical Company, the State of Colorado, and EPA (collectively known as Memorandum of Agreement (MOA) parties) along with their contractors to discuss the technical approach to be used for the well closure program.
July 1, 1987	PMRMA submitted the draft Technical Plan (Task Order 37) to MOA parties for review and comments.
July 29, 1987	PMRMA received Shell Chemical Company's comments on Task 37 Technical Plan.
August 17, 1987	Ebasco initiated first level field search for abandoned wells at RMA.
September 28, 1987	PMRMA received comments from EPA on Task 37 Technical Plan.
October 30, 1987	PMRMA directed Ebasco to stop work on Task 37 until Decision Document can be prepared.
January 7, 1988	PMRMA received comments from the State of Colorado on Task 37 Technical Plan.
February 22, 1988	PMRMA received comments from the U.S. Department of the Interior (DOI) on Task 37 Technical Plan.

March 3, 1988	Ebasco submitted the Final Task 37 Technical Plan to PMRMA.
March 1988	PMRMA submitted the Proposal Decision Document for IRA for the closure of abandoned wells at RMA to MOA parties for review and comment.
April 23, 1988	PMRMA received comments from EPA on the Proposed Decision Document.
May 3, 1988	PMRMA received comments from the State of Colorado on the Proposed Decision Document.
June 1988	PMRMA issued the Final Decision Document for the Interim Response Action for the Closure of Abandoned Wells at RMA. This Decision Document outlines the IRA objectives, broadly defined the number of wells to be closed, procedures for well closure and schedule for the implementation of this IRA.
September 23, 1988	Ebasco submitted the draft Final Report on the Abandoned Well Program (Task Order 37). This report identified 410 wells that were included in Task 37. Of these 410 wells, Ebasco closed 39 wells and could not locate 15 wells after the second search.
September 30, 1988	PMRMA awarded WESTON Task IRA-3: RMA Abandoned Well Closure under a new Contract Number DAAA15-88-R-0023. The scope of this Task Order is to close 350 wells.

1.2 OBJECTIVES OF IRA-3

Objectives of this task (IRA-3) are:

- To locate and abandon wells not previously addressed under Task 37.
- To conduct field searches for 350 abandoned wells including measurements of important well parameters and conditions, to whatever extent practical, and possibly some limited sampling and analysis.
- To properly close 350 abandoned wells located through the field searching efforts.

1.3 DESCRIPTION OF THE IRA WORK AREA

RMA is geographically divided into 28 sections (see Figure 1-2). The focus of IRA-3 will be on those sections where previous efforts (under Task 37) identified 410 wells for closure. These abandoned wells are located in Sections 2, 3, 4, 9, 19, 22, 23, 24, 25, 26, 27, 28, 30, 31, 33, 34, 35, and 36.

Since the activities involved in this Task Order require knowledge of past disposal practices at RMA, general conditions at RMA and the wildlife habitats at RMA, a general description of each of these areas is included in the following subsections.

1.3.1 Past Disposal Practices

Disposal practices on the arsenal are known to have included the following:

- disposal of waste effluents to unlined evaporation ponds,
- burial of solid waste, and
- unintentional release of raw materials, process intermediates, and end products.

The spills were concentrated within the manufacturing complexes and disposal activities were concentrated primarily in Sections 26 and 36.

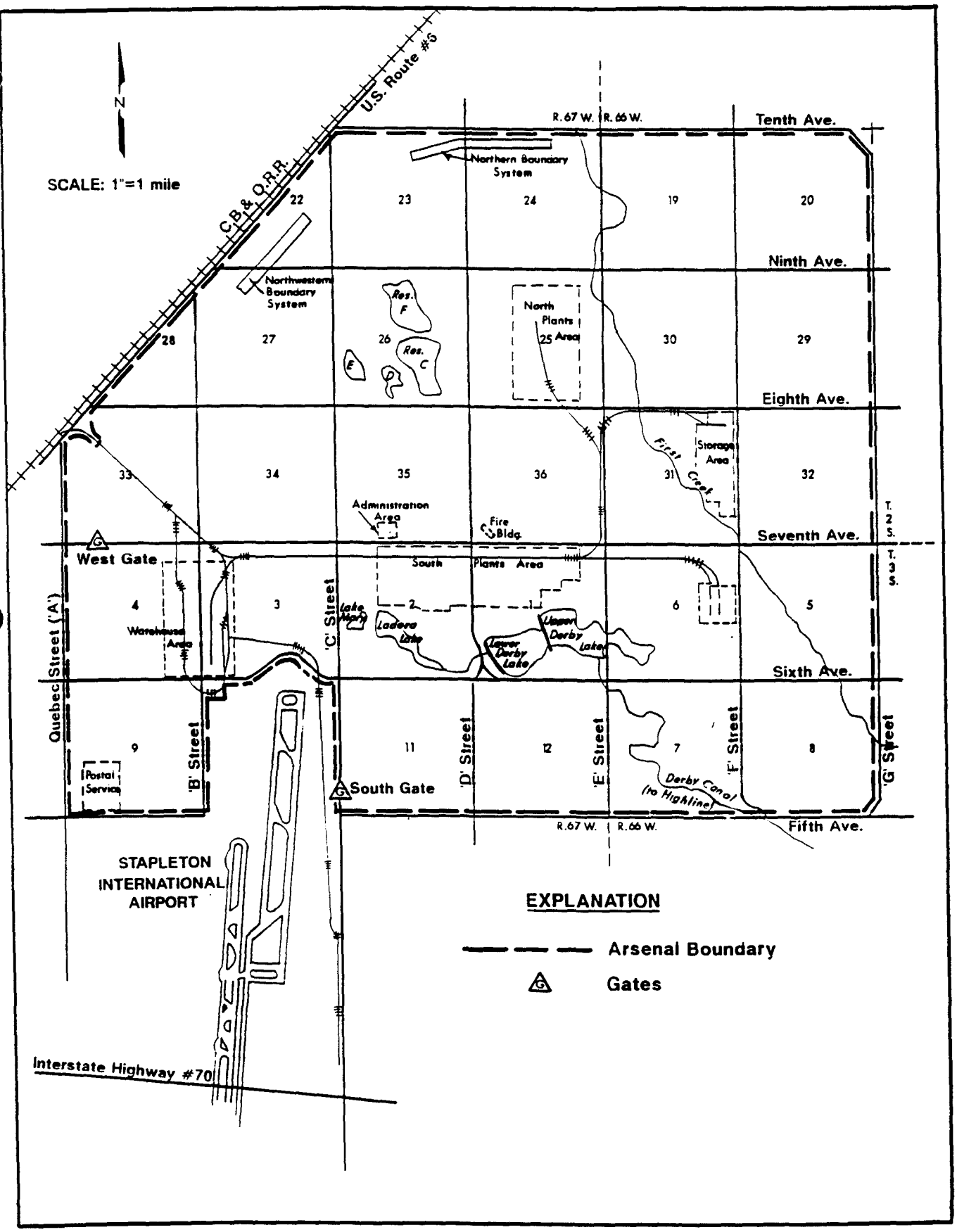


Figure 1-2: ROCKY MOUNTAIN ARSENAL AREA PLAN

1.3.2 Geology

The Rocky Mountain Arsenal is located in the Denver Basin geologic province, a large (483 km or 300 miles long by 322 km or 200 miles wide) north/south trending structural depression resulting from tectonic adjustments (Figure 1-3). Its configuration resulted from normal faulting and subsequent regional uplift associated with the Laramide Orogeny which occurred during the late Cretaceous-Tertiary. The mountains of the Front and Laramie Ranges bound the basin on the west, the Hartville Uplift and Chadron Arch bound the basin on the north, and the Las Animas Arch and Apishapa Uplift bound the basin on the south.

Stratigraphically, unconsolidated surficial sediments, composed of Quaternary Age alluvial and colluvial sands, silts, and clays, and eolian sands, unconformably overlie a bedrock composed of interbedded sandstone, conglomerate, siltstone, and shale mapped as the Denver Formation of late Cretaceous to early Tertiary Age. These sedimentary strata overlie the Precambrian basement rock (Figures 1-4 and 1-5). The regional dip of the rock strata is to the southeast.

The thickness of the unconsolidated sediments ranges from a few feet to over 115 feet. These thicker sequences represent areas where episodes of extensive erosion removed great thicknesses of the Denver Formation creating paleochannels that underlie the surficial deposits on RMA (Costa & Bilodeau, 1982). The Denver Formation varies in thickness from 230 feet to approximately 390 feet above the Arapahoe Formation, the next lower bedrock formation in the sequence.

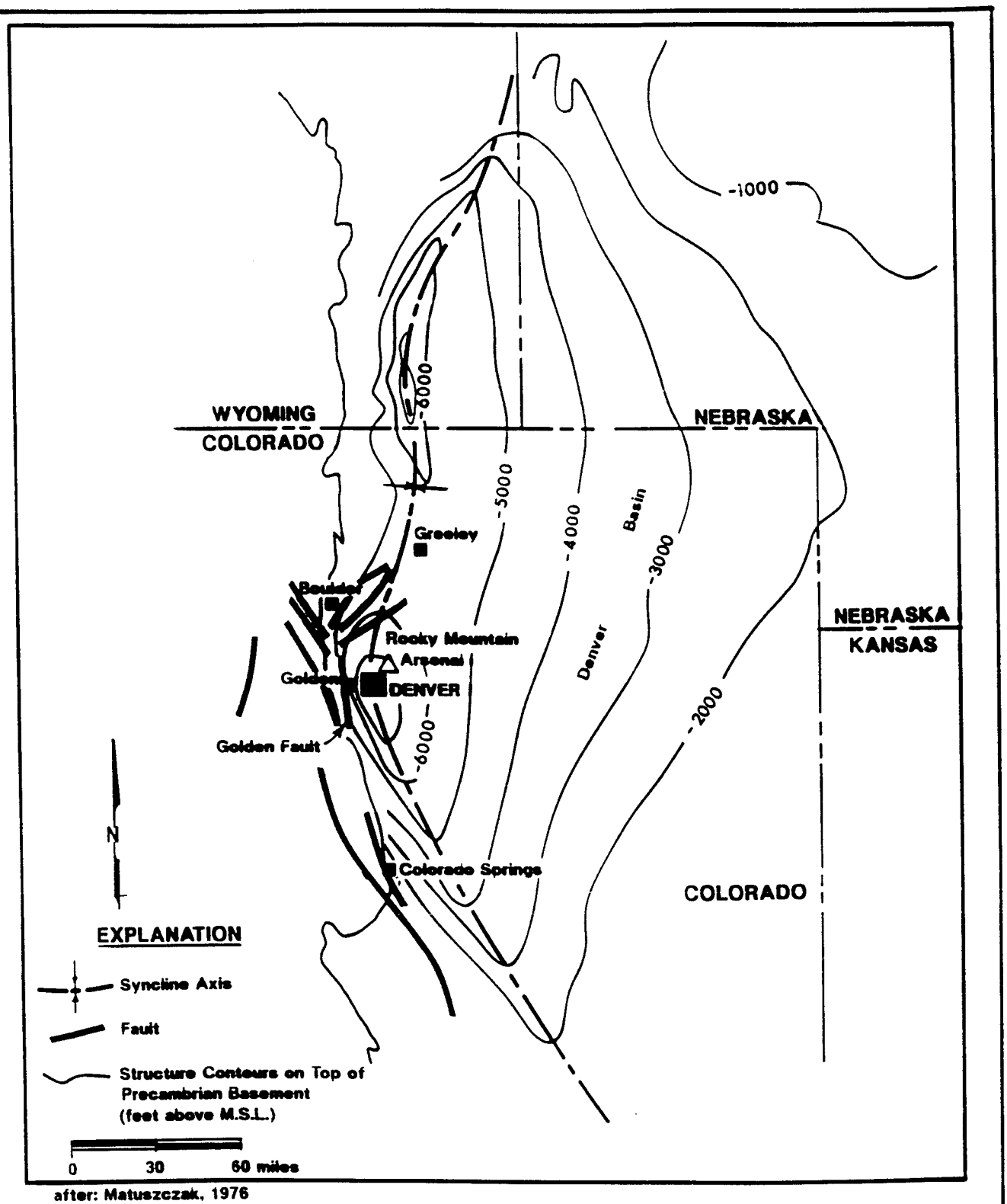
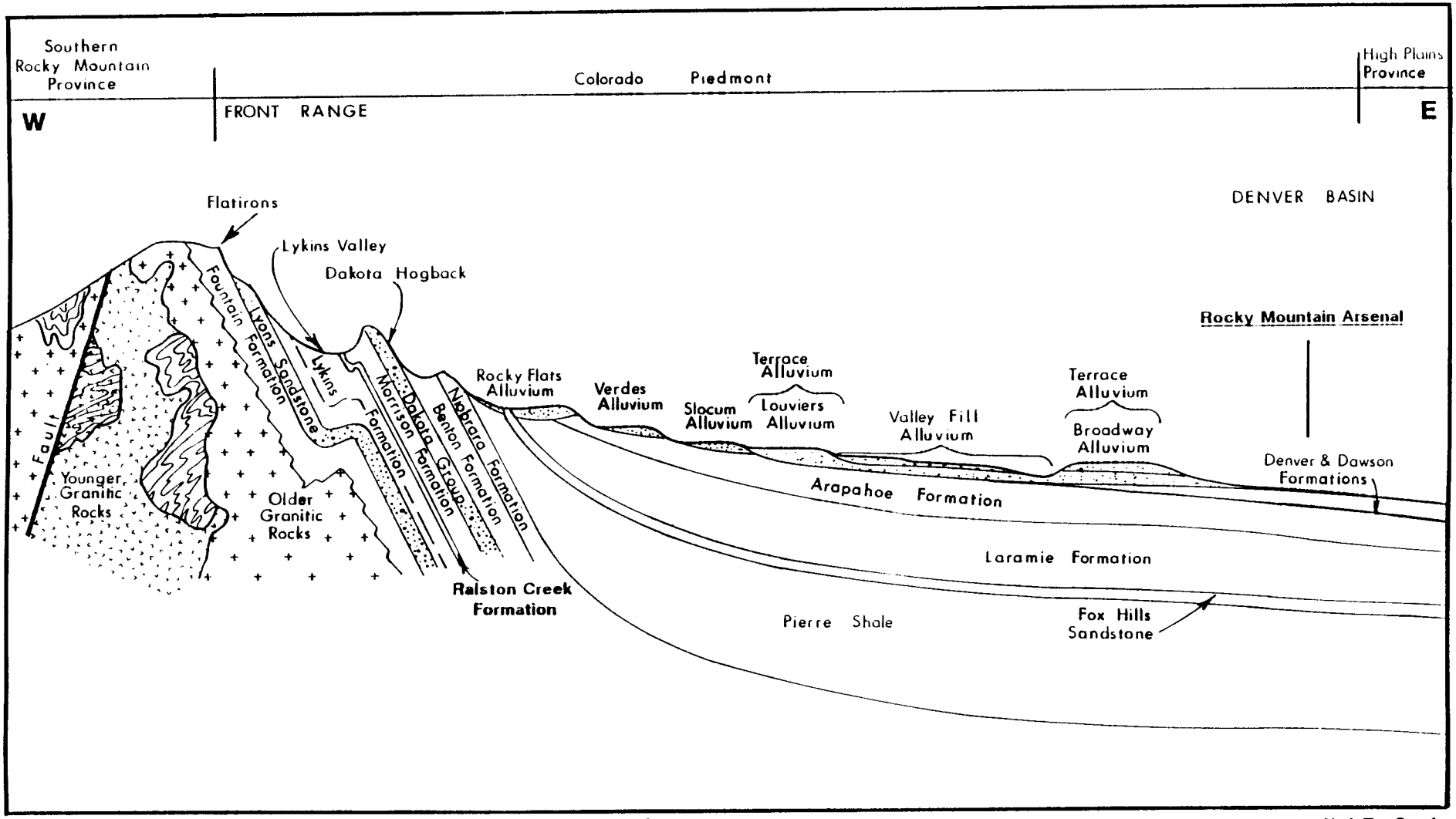


Figure 1-3: STRUCTURE OF THE DENVER BASIN



(after: Boulder County Planning Commission, 1983 and Scott, 1960)

Not To Scale

Figure 1-4: GENERALIZED EAST-WEST CROSS SECTION FRONT RANGE TO DENVER BASIN

ERA	SYSTEM OR PERIOD	SERIES	GEOLOGIC UNIT	
Cenozoic	Quaternary	Recent and Pleistocene	Quaternary Surficial Deposits	stream channel, flood-plain and terrace deposits, eolian sand.
	Tertiary	Oligocene	Castle Rock Congolomerate	
			Tertiary Intrusive and Extrusive Rocks	
Cenozoic and Mesozoic	Tertiary and Cretaceous		Dawson Group	Dawson Arkose
				Denver Formation
				Arapahoe Formation
Mesozoic	Cretaceous		Laramie Formation	Upper Part
				B Sandstone
				A Sandstone
			Fox Hills Sandstone	Milliken Sandstone
				Lower Part
			Pierre Formation	
			Niobrara Formation	Smoky Hill Shale
				Fort Hayes Limestone
			Benton Formation	Carlile Shale
				Greenhorn Limestone
				Graneros Shale
		Lower Cretaceous	Dakota Group	South Platte Formation
				Lytle Formation
	Jurassic	Upper Jurassic	Morrison Formation	
			Ralston Creek Formation	
Paleozoic	Triassic and Permian		Lykins Formation	Strain Shale
				Glennon Limestone
				Bergan Shale
				Falcon Limestone
				Harriman Shale
	Permian		Lyons Sandstone	
	Pennsylvanian		Fountain Formation	
			Glen Eyre Formation	
	Mississippian		Madison Limestone	
			Williams Canyon Limestone	
	Ordovician and Cambrian		Manitou Dolomite	
	Cambrian		Sawatch Sandstone	
Precambrian			crystaline rocks	

(after: Romero, 1976)

Figure 1-5: GENERALIZED COMPOSITE SECTION OF THE GEOLOGIC UNITS OF THE DENVER BASIN

1.3.3 Groundwater Hydrology

Unconfined groundwater conditions are found in the unconsolidated deposits beneath RMA. The transmissivity of the unconsolidated deposits varies due to the heterogeneity of the sediment. Test results from previous studies at RMA indicate transmissivities ranging from less than 20 gpd/foot (gallons per day per foot) to greater than 5,000 gpd/foot. Paleochannels incised into the bedrock surface serve as groundwater transport pathways in the unconsolidated deposits due to the generally coarse nature of the sediments in these channels. The four paleochannels of off-site contaminant transport significance are the Northern, First Creek, Western Bifurcation of First Creek, and the Northwest Boundary. Water level measurements from wells completed in the unconsolidated sediments indicate a potentiometric surface that slopes to the northwest. Water levels in the unconsolidated deposits fluctuate seasonally and in response to pumping of off-site irrigation and municipal wells.

Groundwater in the bedrock is under confined conditions as indicated by test results in Well 37365. Transmissivities in this well, which penetrates the Denver Formation, range from 3 to 14 gpd/foot. Groundwater in the bedrock will move through fractures in the rock and through the coarser-grained, more-permeable sandstones. Water level measurements during previous studies indicate that the potentiometric surface in the bedrock slopes northwesterly. There is also a downward vertical gradient between the alluvium and Denver Formation that decreases to the north.

1.3.4 Wildlife Habitats

The Army will review on a weekly basis with U.S. Fish and Wildlife, during the bald eagle wintering period, the schedule of projected abandoned well closure activities in order to protect the free movement of eagles at RMA. In addition, some abandoned well sites that include bald eagle roosts or foraging areas, such as the designated Endangered

Species Management Area at RMA (shown in Figure 1-6) and around the Derby Lakes and Lake Ladora, may need to be off-limits for well closure activities, to the extent determined by U.S. Fish and Wildlife, until the bald eagles depart in the spring.

1.4 SUMMARY OF THE TECHNICAL APPROACH

The objectives of IRA-3 include the identification, location, and closure of abandoned wells on RMA. It is currently thought that at least 350 wells will be closed to prevent migration of ground water between aquifers. The scope of the work includes: compilation of a well inventory and data base, field location of wells, compilation of a list of wells to be closed, cleaning and closure of 350 of the insert figure 1-6 identified wells, and documentation of closure activities. This scope of work is detailed in the following sections and summarized in Figure 1-7, the list of 410 wells identified under Task 37 will be the starting point for the closure of wells under IRA-3. These wells were identified as high priority wells for closure. To date only 39 of these wells have been closed and 15 have not been located upon the completion of second level search. The technical approach described herein is based on the direction provided in the Final Decision Document for the Interim Response Action for the Closure of Abandoned Wells at Rocky Mountain Arsenal (June 1988).

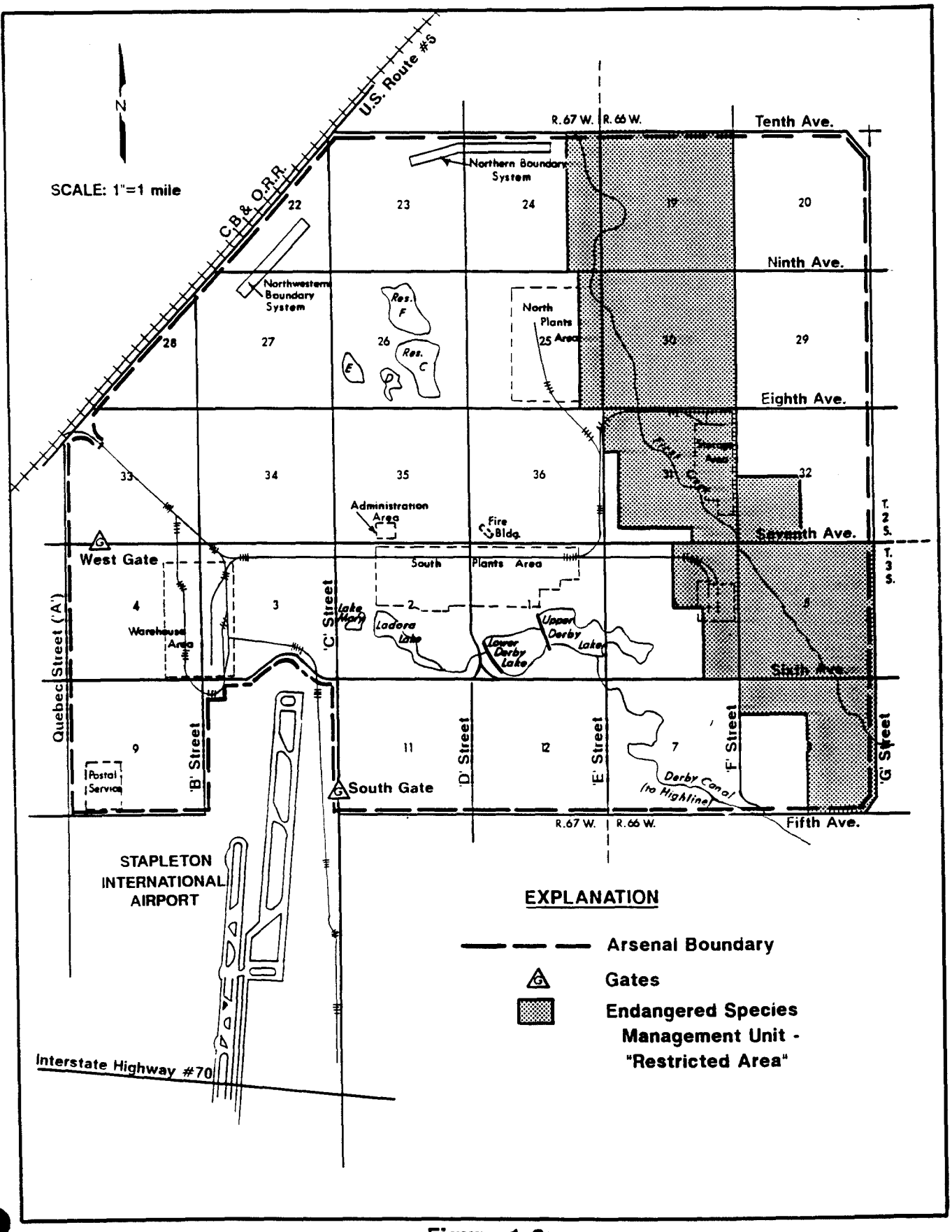
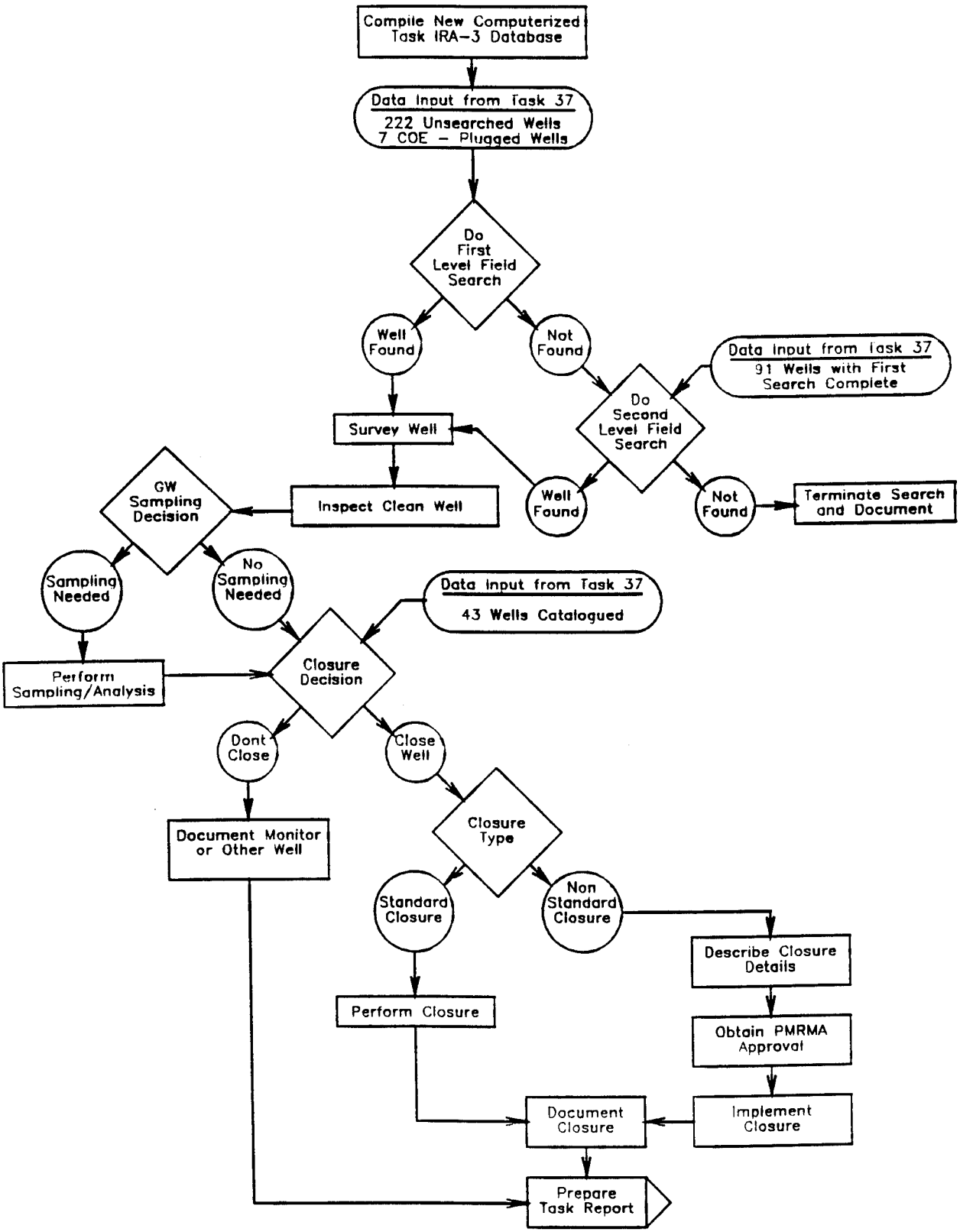


Figure 1-6:
ENDANGERED SPECIES MANAGEMENT UNIT - Rocky Mountain Arsenal

OVERALL LOGIC
TASK IRA–3 FIGURE 1–7



SECTION 2

ABANDONED WELL IDENTIFICATION AND LOCATION

2.1 COMPILATION OF WELL INVENTORY CLOSURE LIST

The compilation of a well inventory closure list for this task will be based on the list of wells identified under Task 37 for potential closure. Current information and data collected during field activities pertaining to the wells identified for high priority closure in Task 37 will be included in a computerized database. The computerized database will be the basis for planning the field search and actual well closure activities. It will provide an organized means for establishing priorities in the deployment of equipment and manpower resources.

2.1.1 Well Database Compilation

Several databases for wells at RMA have been compiled in the past (i.e., Task 37 Database, RMA Information Center Database, etc.) but none of these have been comprehensive in documenting all of the pertinent well characteristics. The database being developed by the Army for Task IRA-3 will be capable of documenting the historical well construction and closure data, assisting in the planning of well closures, and documenting well status information. The major categories of well data which will be collected in the database include:

1. Well identification and location;
2. Formation/stratigraphy;
3. Well casings/backfill/seals;
4. Well screens/packing;
5. Open borehole sections;
6. Well security casing/sanitary seal/equipment;

7. Well search methods;

8. Well component conditions when located;

9. Well closure activities; and

10. Final well status.

An example of the type of information (partial) to be included in the new database is provided in Table 2-1, which describes wells located in Section 9. Figures 2-1 and 2-2 depict the major typical components of well construction which will be included in the database. Appendix A presents the subject headings included in the database file structure.

2.1.2 Initial Well Closure List

The initial entries into the Task IRA-3 well closure list will be derived from the results of the Task 37 evaluation of wells in critical or high risk areas of RMA. Additions and/or deletions to the initial well closure list will be made by PMRMA upon completion of a detailed review of well status for all wells located on RMA. The search and closure status for all wells currently under consideration for closure under Task IRA-3 is presented in Table 2-2. Those wells for which closure approval has been granted are listed as approved. Wells indicated as being under consideration for closure are subject to additional review prior to being approved.

The database for these wells will be initially established from information available in the Task 37 and RMA Information Center Databases. This information will be electronically transferred into the new database, and then supplemented by:

Table 2-1

SECTION 09 WELLS

ROCKY MOUNTAIN ARSENAL
GROUNDWATER WELL STATUS SUMMARY

SECT	WELL NO.	BORE NO.	GRID NO.	TOWN AND RANGE	STATE EASTING	STATE NORTHING	SURFACE ELEV (ft)	YEAR WELL CNST	WELL PURP	DRILL OR DUG?	BORE DEPTH (ft.)	AQF	LOCATD ?	STATUS OPEN?	PRELIM ABAND LIST	STATUS CLSD?	TO BE CLSD?	CLOSR PRIOR	MORE NOTES ?
09	001	49	09BCB		2168240	173770	5194.00	1986	MON	DRILL	61.1	ALL	Yes	-	-	-	-		-
09	002	1135	09BAC		2169602	174028	5207.90	1980	MON	DRILL	84.0	ALL	Yes	-	-	-	-		-
09	003	1135	09BAC		2169602	174028	5208.97	1980	MON	DRILL	84.0	DEN	Yes	-	-	-	-		-
09	004	1135	09BAC		2169602	174028	5208.09	1986	MON	DRILL	84.0	DEN	Yes	-	-	-	-		-
09	005	POGW02	09CAC		2169186	171940	5210.10	1986	MON	DRILL	78.0	ALL	Yes	-	-	-	-		-
09	006	POGW01	09CBA		2168551	171990	5200.00	1986	MON	DRILL	68.2	ALL	Yes	-	-	-	-		-
09	007	POGW03	09CCC		2168195	170187	5210.80	1986	MON	DRILL	67.5	ALL	Yes	-	-	-	-		-
09	008		09DCA		2171411	171154	5216.95	1986	MON	DRILL	76.0	ALL	Yes	-	-	-	-		-
09	009		09DCA		2171420	171157	5216.98	1986	MON	DRILL	76.0	ALL	Yes	-	-	-	-		-
09	010		09AAB		2172016	175169	5204.77	1986	MON	DRILL	85.0	ALL	Yes	-	-	-	-		-
09	011		09ACA		2171081	173598	5210.81	1986	MON	DRILL	90.0	ALL	Yes	-	-	-	-		-
09	012		09ACA		2171091	173601	5210.89	1986	MON	DRILL	90.1	ALL	Yes	-	-	-	-		-
09	013		09DCD		2171502	170073	5221.08	1987	MON	DRILL	79.0	ALL	Yes	-	-	-	-		-
09	014		09DCD		2171514	170081	5221.54	1987	MON	DRILL	60.0	ALL	Yes	-	-	-	-		-
09	015		09ADD		2173008	172741	5225.80	1987	MON	DRILL	37.2	ALL	Yes	-	-	-	-		-
09	A01			03S 67W NW NE				P 42	FARM		R34		-	-	Yes	-	-		-
09	A02			03S 67W NW NE	2171218	175111	5209.77	P 42	FARM	DRILL	R900		Yes	-	Yes	-	-		-
09	A03			03S 67W NW NE	2170499	175177	5204.02	P 42	FARM	DRILL	R500		Yes	-	Yes	-	-		-
09	A04			03S 67W NE NW	2169613	175149	5201.43	P 42	FARM	DRILL	R75		Yes	-	Yes	Yes	-		-
09	A05			03S 67W SW SW				P 42	FARM		R1000		-	-	Yes	-	-		-
09	A06			03S 67W NW NW				P 42	FARM		R56		-	-	Yes	-	-		-
09	A07			03S 67W NW NW	2168864	174563	5198.80	P 42	FARM	DRILL	R77		Yes	-	Yes	Yes	-		-
09	A08			03S 67W SE SW	2170332	170716	5213.17	P 42	FARM	DUG	R44		Yes	-	Yes	Yes	-		-
09	A09			03S 67W SW NW	2168930	173065	5199.91	P 42	FARM	DUG	R55		Yes	-	Yes	-	-		-
09	A10			03S 67W SW SW				P 42	FARM		R1000		-	-	Yes	-	-		-
09	A11			03S 67W SE SW				P 42	FARM		R800		-	-	Yes	-	-		-
09	A12			03S 67W NW SW				P 42	FARM		R73		-	-	Yes	-	-		-
09	A13			03S 67W NW SW	2168779	172263	5209.24	P 42	FARM	DRILL			Yes	-	Yes	Yes	-		-
09	A14			03S 67W SW NW	2167904	173543	5195.90	P 42	FARM	DUG	R52		Yes	-	Yes	-	-		-
09	A15			03S 67W SE SW				P 42	FARM				-	-	Yes	-	-		-
09	A16			03S 67W NW NE				P 42	FARM		R76		-	-	Yes	-	-		-
09	A17			03S 67W NW SW	2168151	171859	5208.22	P 42	FARM	DRILL	R61		Yes	-	Yes	Yes	-		-
09	A18			03S 67W NE NW	2169770	175194	5200.47	P 42	FARM	DRILL	R72		Yes	-	Yes	Yes	-		-
09	A19			03S 67W NW NW				P 42	FARM		R54		-	-	Yes	-	-		-
09	A20			03S 67W SW NW				P 42	FARM	DRILL	R58		Yes	-	Yes	-	-		-

Table 2-1(c[redacted].)

SECTION 09 WELLS

ROCKY MOUNTAIN ARSENAL
GROUNDWATER WELL CONSTRUCTION

SECT	WELL NO.	BORE NO.	YEAR WELL CNST	DRILL OR DUG?	WELL PURP	AQFR	SURFACE ELEV (ft)	BORE DEPTH (ft)	DEPTH FIRST WATER (ft)	CASE LENGTH (ft)	STICK UP (ft)	CASE DIAM (in)	CASE MAT?	NO. SCRN INT?	TOP OF SCREEN (ft)	SCREEN LENGTH (ft)	TOP OF SEAL DEPTH (ft)	BOT OF SEAL DEPTH (ft)	SEAL MAT?	TOP OF GROUT DEPTH (ft)	BOT OF GROUT DEPTH (ft)	BORE NOTES
09	001	49	1986	DRILL	MON	ALL	5194.00	61.1	48.2	63.5	0.9	4.0	PLS	1	55.0	6.6						-
09	002	1135	1980	DRILL	MON	ALL	5207.90	84.0		89.0	2.3	2.0		1	64.0	20.0	54.0	59.0	BEN			-
09	003	1135	1980	DRILL	MON	DEN	5208.97	84.0		134.0	2.0	2.0	PVC	1	104.0	25.0	95.0	100.0	BEN	SURFACE	95.0	-
09	004	1135	1986	DRILL	MON	DEN	5208.09	81.0		198.5	2.5	2.0	PVC	1	181.0	15.0	171.0	176.0	BEN	SURFACE	171.0	-
09	005	POGW02	1986	DRILL	MON	ALL	5210.10	78.0	59.0	77.0	2.1	4.0	PVC	1	51.5	25.5	43.0	48.0	BEN	SURFACE	43.0	-
09	006	POGW01	1986	DRILL	MON	ALL	5200.00	68.2	49.5	67.3	1.9	4.0	PVC	1	41.8	25.5	33.0	38.0	BEN	SURFACE	33.0	-
09	007	POGW03	1986	DRILL	MON	ALL	5210.80	67.5	56.0	67.3	2.1	4.0	PVC	1	51.8	15.4	44.0	48.5	BEN	SURFACE	44.0	-
09	008		1986	DRILL	MON	ALL	5216.95	76.0	44.5	77.3	2.5	4.0	PVC	1	58.1	15.0	41.0	45.5	BEN	SURFACE	41.0	-
09	009		1986	DRILL	MON	ALL	5216.98	76.0	44.5	57.6	2.4	4.0	PVC	1	42.6	15.0	34.5	40.0	BEN	SURFACE	34.5	-
09	010		1986	DRILL	MON	ALL	5204.77	85.0	64.5	84.0	2.6	4.0	PVC	1	64.0	20.0	52.5	58.7	BEN	SURFACE	52.5	-
09	011		1986	DRILL	MON	ALL	5210.81	90.0	64.0	87.7	2.3	4.0	PVC	1	72.7	14.5	63.5	69.0	BEN	SURFACE	63.5	-
09	012		1986	DRILL	MON	ALL	5210.89	90.1		75.0	2.2	4.0	PVC	1	60.0	15.0	50.0	55.0	BEN	SURFACE	50.0	-
09	013		1987	DRILL	MON	ALL	5221.08	79.0	39.0	75.0	2.0	4.0	PVC	1	55.0	20.0	36.5	42.0	BEN	SURFACE	36.5	-
09	014		1987	DRILL	MON	ALL	5221.54	60.0		57.4	2.3	4.0	PVC	1	37.4	20.0	27.0	32.5	BEN	SURFACE	27.0	-
09	015		1987	DRILL	MON	ALL	5225.80	37.2		36.9	2.3	4.5	PVC	1	27.2	9.7	17.6	22.1	BEN	SURFACE	17.6	-
09	A01		P 42		FARM			R34				-										-
09	A02		P 42	DRILL	FARM		5209.77	R900				-	STL									-
09	A03		P 42	DRILL	FARM		5204.02	R500				4	STL									-
09	A04		P 42	DRILL	FARM		5201.43	R75				6	GAL									-
09	A05		P 42		FARM			R1000				30										-
09	A06		P 42		FARM			R56				6										-
09	A07		P 42	DRILL	FARM		5198.80	R77				-	GAL									-
09	A08		P 42	DUG	FARM		5213.17	R44				36	BRK									-
09	A09		P 42	DUG	FARM		5199.91	R55				40	CON									-
09	A10		P 42		FARM			R1000				-										-
09	A11		P 42		FARM			R800				-										-
09	A12		P 42		FARM			R73				-										-
09	A13		P 42	DRILL	FARM		5209.24					-	STL									-
09	A14		P 42	DUG	FARM		5195.90	R52				36	CON									-
09	A15		P 42		FARM							-										-
09	A16		P 42		FARM			R76														-
09	A17		P 42	DRILL	FARM		5208.22	R61				6	GAL									-
09	A18		P 42	DRILL	FARM		5200.47	R72				6	GAL									-
09	A19		P 42		FARM			R54				-	STL									-
09	A20		P 42	DRILL	FARM			R58				6										-

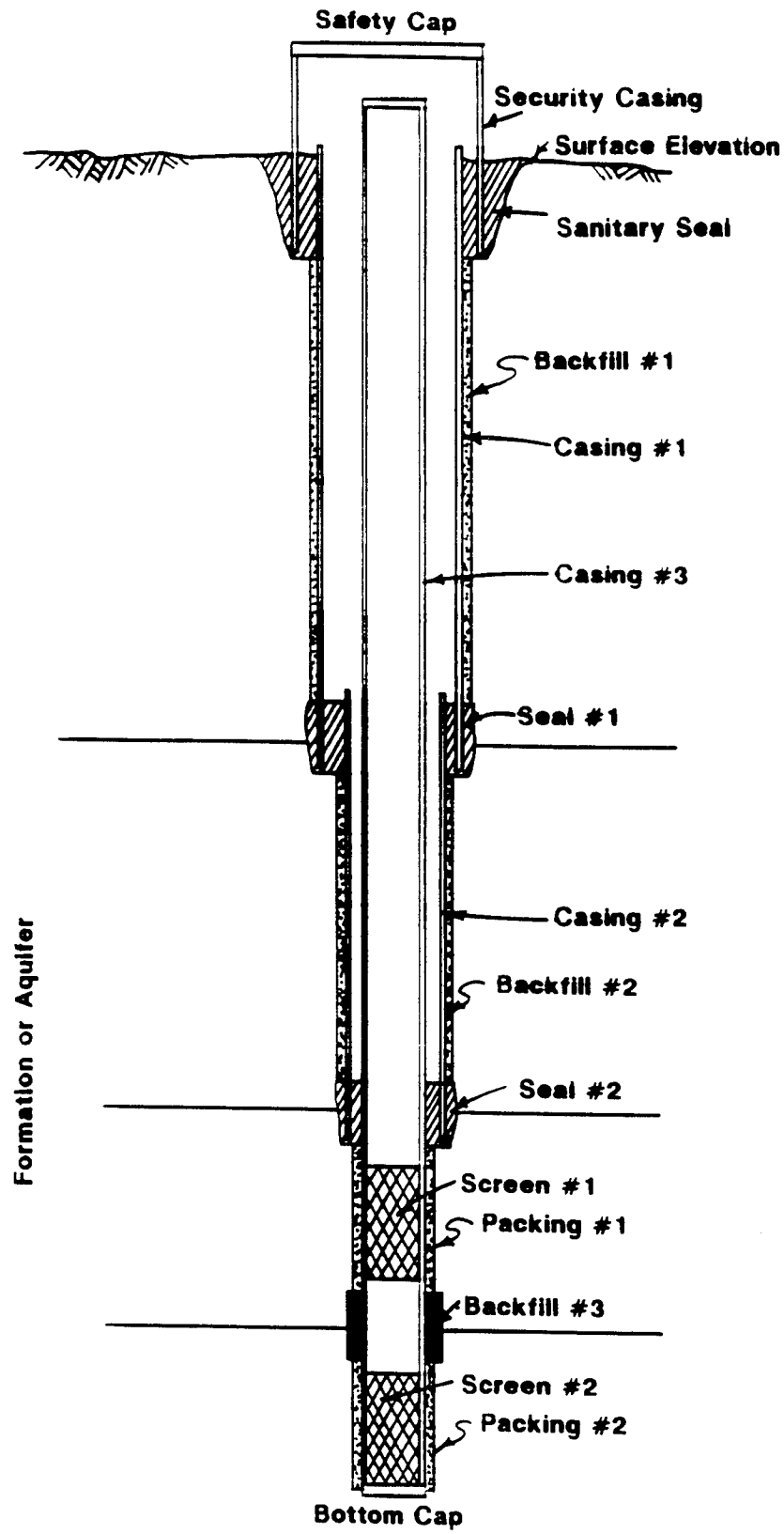


Figure 2-1: SCREENED WELL

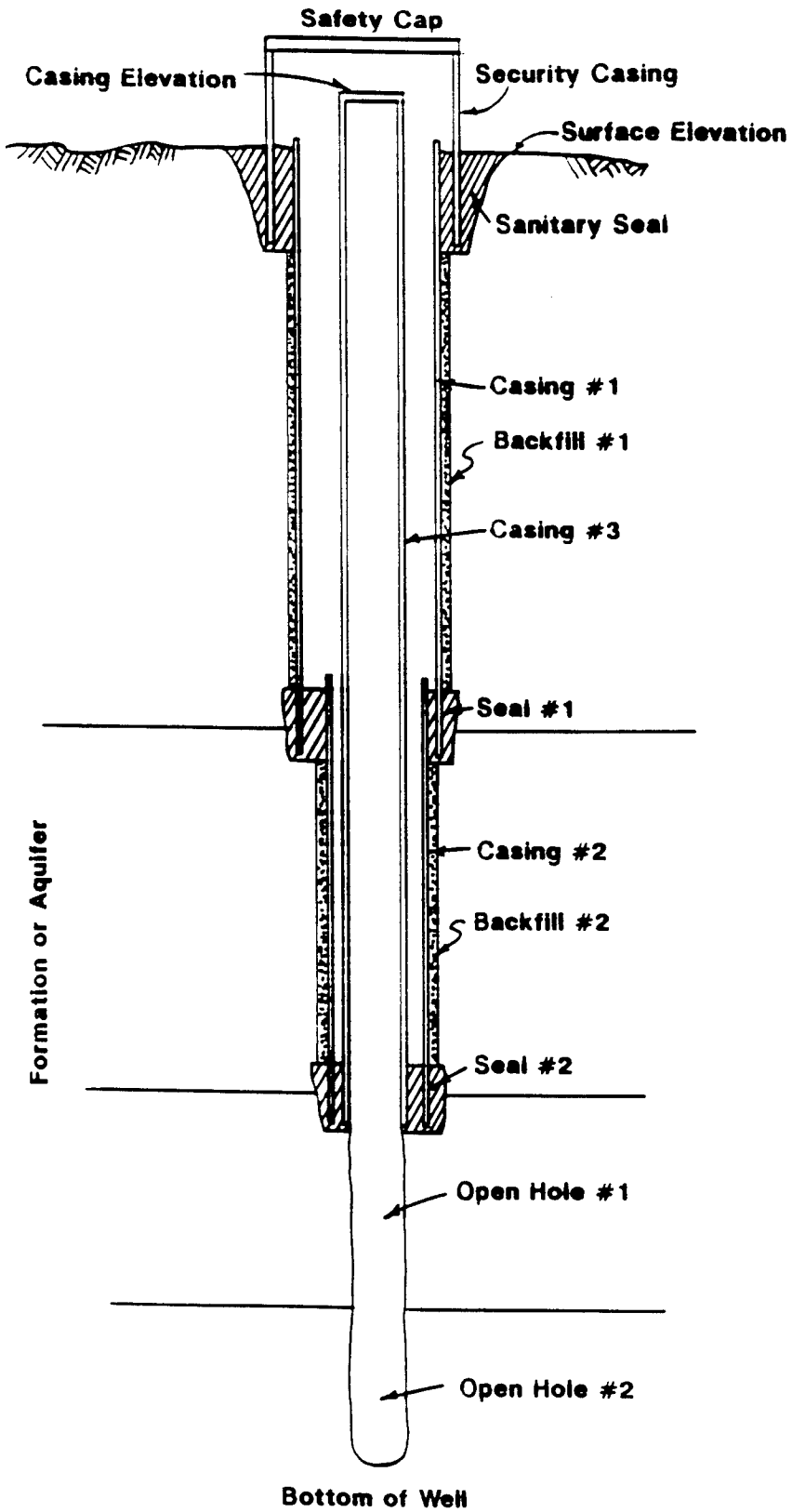


Figure 2-2: UNSCREENED WELL

TABLE 2-2

CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
** SECTION 01										
01 005	2183905	180371		04/17/89	No	--	-	--	-	-
01 006	2184656	180473		04/17/89	No	--	-	--	-	-
01 009	2184922	180431		--	-	--	-	--	-	-
01 057	2184957	179957		04/17/89	Yes	--	-	--	-	-
01 058	2184920	180214		04/17/89	Yes	--	-	--	-	-
01 059	2184943	179868		04/17/89	Yes	--	-	--	-	-
01 060	2185072	179863		04/17/89	Yes	--	-	--	-	-
01 062	2185132	179357		04/17/89	Yes	--	-	--	-	-
** SECTION 02										
02 A01	2183025	175669	SE SE	--	-	--	-	--	-	T-37
02 A02	-	-	SE SW	--	-	--	-	--	-	-
02 A03	2179039	177908	NW SW	--	-	--	-	--	-	T-37
02 A04	-	-	NW SW	03/27/89	No	--	-	--	-	-
02 A05	2179321	178581	SW NW	03/13/89	Yes	--	-	--	-	-
** SECTION 03										
03 A01	-	-	SE SE	02/23/89	Yes	--	-	--	-	-
03 A02	-	-	SE SE	02/23/89	Yes	--	-	--	-	-
03 A03	2178147	176379	SE SE	02/23/89	Yes	--	-	--	-	-
03 A04	2178025	176992	NE SE	--	-	--	-	--	-	T-37
03 A05	-	-	NW NE	02/23/89	No	--	-	--	-	-
03 A06	-	-	NE NW	02/23/89	Yes	--	-	--	Yes	04/25/89
03 A07	2173748	179319	NW NW	02/23/89	Yes	--	-	--	-	-
03 A08	-	-	NW SW	02/23/89	Yes	--	-	--	-	-
03 A09	2174144	175355	SW SW	02/23/89	Yes	--	-	--	-	-
03 A10	-	-	SE SW	--	-	--	-	--	-	-
03 A12	-	-	SE SW	04/14/89	No	--	-	--	-	-
03 A13	-	-	NW SE	02/23/89	Yes	--	-	--	-	-
03 A15	-	-	NE SW	02/24/89	Yes	--	-	--	-	-
03 A16	-	-	NW SE	02/23/89	Yes	--	-	--	-	-
03 A19	-	-	NE SE	02/23/89	Yes	--	-	--	-	-
03 A20	-	-	NW SE	02/23/89	Yes	--	-	--	-	-
03 A21	-	-	NE SE	02/23/89	No	--	-	--	-	-
03 A22	-	-	SE SE	02/23/89	No	--	-	--	-	-
03 A23	-	-	NE SW	--	-	--	-	--	-	-
03 A24	-	-		--	-	--	-	--	-	-
03 AGM1	-	-	SW SW	--	-	--	-	--	-	-

TABLE 2-2

CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
** SECTION 04										
04 001	2169595	179096		04/27/89	Yes	--	-	--	-	-
04 005	2172879	180470		04/27/89	No	--	-	--	-	-
04 006	2173392	177979		04/27/89	No	--	-	--	-	-
04 034	2172400	179198		04/27/89	Yes	--	-	--	-	-
04 A01	-	-	SW SW	02/17/89	No	--	-	--	-	-
04 A02	-	-	SW SW	02/17/89	No	--	-	--	-	-
04 A03	2170294	177652	NW SE	02/16/89	Yes	--	-	--	-	-
04 A04	2168407	176794	NW SW	02/16/89	No	--	-	--	-	-
04 A05	-	-	SE SW	02/17/89	Yes	--	-	--	-	-
04 A06	2167876	177854	SW NW	02/16/89	Yes	--	-	--	-	-
04 A07	-	-	NE SW	03/27/89	No	--	-	--	-	-
04 A08	2168465	177795	NW SW	02/16/89	No	--	-	--	-	T-37
04 A09	-	-	SE SW	02/17/89	No	--	-	--	-	-
04 A10	2174144	175355	SE SW	02/17/89	Yes	--	-	--	-	T-37
04 A11	-	-	SE SW	02/17/89	Yes	--	-	--	-	-
04 A12	-	-	NW NW	--	-	--	-	--	-	-
04 A13	-	-	SW NE	--	-	--	-	--	-	-
04 A14	-	-	SW NE	02/16/89	No	--	-	--	-	-
04 AGM1	2168609	175735	SW SW	02/17/89	Yes	--	-	--	-	T-37
04 AGM2	2168558	175702	SW SW	02/17/89	Yes	--	-	--	-	-
** SECTION 05										
05 A01	-	-		04/03/89	Yes	--	-	--	-	-
05 A02	-	-		04/03/89	No	--	-	--	-	-
05 A03	-	-		04/03/89	No	04/12/89	No	--	-	-
05 A04	-	-		04/03/89	No	04/12/89	No	--	-	-
** SECTION 06										
06 A01	-	-		03/28/89	No	--	-	--	-	-
06 A02	-	-		03/28/89	No	--	-	--	-	-
06 A03	-	-		03/28/89	No	--	-	--	-	-
06 A04	-	-		03/28/89	No	--	-	--	-	-
06 A05	-	-		03/28/89	Yes	--	-	--	-	-
06 A06	-	-		03/28/89	Yes	--	-	--	Yes	04/04/89
** SECTION 08										
08 A01	-	-		04/03/89	Yes	--	-	--	-	-
** SECTION 09										
09 A01	-	-	NW NE	11/02/88	No	--	-	--	-	-

TABLE 2-2

CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
09 A02	2171218	175111	NW NE	10/26/88	Yes	--	-	--	-	-
09 A03	2170499	175177	NW NE	10/26/88	No	--	-	--	-	-
09 A04	2169613	175149	NE NW	--	-	--	-	--	-	T-37
09 A05	-	-	SW SW	11/02/88	Yes	--	-	--	-	-
09 A06	-	-	NW NW	10/27/88	No	--	-	--	-	-
09 A07	2168864	174563	NW NW	10/27/88	Yes	--	-	--	-	T-37
09 A08	2170332	170716	SE SW	--	-	--	-	--	-	T-37
09 A09	2168930	173065	SW NW	10/27/88	Yes	--	-	--	-	-
09 A10	-	-	SW SW	03/27/89	No	--	-	--	-	-
09 A11	-	-	SE SW	03/27/89	No	--	-	--	-	-
09 A12	-	-	NW SW	11/09/88	No	--	-	--	-	-
09 A13	2168779	172263	NW SW	--	-	--	-	--	-	T-37
09 A14	2167904	173543	SW NW	11/02/88	Yes	--	-	--	-	-
09 A15	-	-	SE SW	03/27/89	No	--	-	--	-	-
09 A16	-	-	NW NE	11/02/88	No	--	-	--	-	-
09 A17	2168151	171859	NW SW	--	-	--	-	--	-	T-37
09 A18	2169770	175194	NE NW	--	-	--	-	--	-	T-37
09 A19	-	-	NW NW	10/27/88	Yes	--	-	--	-	-
09 A20	2168240	173770	SW NW	10/27/88	Yes	--	-	--	-	-
** SECTION 10										
10 A14	-	-		--	-	--	-	--	-	-
10 A17	-	-		--	-	--	-	--	-	-
10 A18	-	-		--	-	--	-	--	-	-
10 A21	-	-		--	-	--	-	--	-	-
10 A22	-	-		--	-	--	-	--	-	-
** SECTION 11										
11 A01	-	-		--	-	--	-	--	-	-
11 A02	-	-		--	-	--	-	--	-	-
11 A03	-	-		--	-	--	-	--	-	-
11 A04	-	-		--	-	--	-	--	-	-
11 A05	-	-		--	-	--	-	--	-	-
11 A06	-	-		--	-	--	-	--	-	-
11 A07	-	-		--	-	--	-	--	-	-
11 A08	-	-		--	-	--	-	--	-	-
11 A09	-	-		--	-	--	-	--	-	-
11 A10	-	-		--	-	--	-	--	-	-
11 A11	-	-		--	-	--	-	--	-	-
11 A12	-	-		--	-	--	-	--	-	-
11 A13	-	-		--	-	--	-	--	-	-

TABLE 2-2

CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
11 A14	-	-		--	-	--	-	--	-	-
11 A15	-	-		--	-	--	-	--	-	-
11 A16	-	-		--	-	--	-	--	-	-
11 A17	-	-		--	-	--	-	--	-	-
11 A18	-	-		--	-	--	-	--	-	-
11 A19	-	-		--	-	--	-	--	-	-
11 A20	-	-		--	-	--	-	--	-	-
11 A21	-	-		--	-	--	-	--	-	-
11 A22	-	-		--	-	--	-	--	-	-
11 A23	-	-		--	-	--	-	--	-	-
11 A24	-	-		--	-	--	-	--	-	-
11 A25	-	-		--	-	--	-	--	-	-
11 A26	-	-		--	-	--	-	--	-	-
11 A27	-	-		--	-	--	-	--	-	-
11 A28	-	-		--	-	--	-	--	-	-
11 A29	-	-		--	-	--	-	--	-	-
** SECTION 12										
12 A01	-	-		--	-	--	-	--	-	-
12 A02	-	-		--	-	--	-	--	-	-
12 A03	-	-		--	-	--	-	--	-	-
12 A04	-	-		--	-	--	-	--	-	-
12 A05	-	-		--	-	--	-	--	-	-
12 A06	-	-		--	-	--	-	--	-	-
12 A07	-	-		--	-	--	-	--	-	-
12 A08	-	-		--	-	--	-	--	-	-
12 A09	-	-		--	-	--	-	--	-	-
12 A10	-	-		--	-	--	-	--	-	-
12 A11	-	-		--	-	--	-	--	-	-
12 A12	-	-		--	-	--	-	--	-	-
12 A13	-	-		--	-	--	-	--	-	-
12 A14	-	-		--	-	--	-	--	-	-
12 A15	-	-		--	-	--	-	--	-	-
12 A16	-	-		--	-	--	-	--	-	-
12 A17	-	-		--	-	--	-	--	-	-
12 A18	-	-		--	-	--	-	--	-	-
12 A19	-	-		--	-	--	-	--	-	-
12 A20	-	-		--	-	--	-	--	-	-
12 A21	-	-		--	-	--	-	--	-	-
12 A22	-	-		--	-	--	-	--	-	-

TABLE 2-2

CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
** SECTION 19										
19 A01	-	-	SW SW	03/31/89	Yes	--	-	--	Yes	04/06/89
** SECTION 20										
20 001	2199066	194984		--	-	--	-	--	-	-
20 A01	-	-		03/28/89	Yes	--	-	--	-	-
20 A02	-	-		03/29/89	No	--	-	--	-	-
20 A03	-	-		03/29/89	No	04/10/89	No	--	-	-
20 A04	-	-		03/29/89	No	--	-	--	-	-
** SECTION 22										
22 002	2176392	193755		01/27/89	Yes	--	-	--	-	-
22 014	2178095	191871		01/27/89	Yes	--	-	--	Yes	03/30/89
22 046	-	-		--	-	--	-	02/03/89	-	-
22 047	2175888	192316		--	-	--	-	--	-	-
22 048	-	-		--	-	--	-	02/03/89	-	-
22 058	-	-		--	-	--	-	--	-	-
22 068	2175888	192316		--	-	--	-	--	-	-
22 074	2175523	192833		--	-	--	-	--	-	-
22 A01	-	-	SW SE	--	-	--	-	--	-	COE
22 A02	2178235	191583	SE SE	01/27/89	Yes	--	-	--	Yes	03/27/89
22 A03	-	-	SW NE	--	-	--	-	--	-	COE
** SECTION 23										
23 001	2181481	195761	NW NE	01/24/89	No	02/10/89	Yes	--	Yes	02/24/89
23 003	2180354	191439	SE SW	11/21/88	Yes	--	-	--	Yes	11/30/88
23 005	2182429	196233	NE NE	01/25/89	No	--	-	--	-	-
23 017	2182851	195959	NE NE	01/24/89	No	02/01/89	No	02/14/89	-	-
23 018	2183101	195961	NE NE	11/22/88	No	12/22/88	No	01/04/89	-	-
23 019	2183351	195963	NE NE	01/24/89	No	--	-	02/03/89	-	-
23 020	2182577	195757	NE NE	01/24/89	No	02/01/89	No	02/03/89	-	-
23 022	2182702	195758	NE NE	01/24/89	No	01/31/89	Yes	--	Yes	02/22/89
23 024	2182727	195758	NE NE	01/24/89	Yes	--	-	--	Yes	02/27/89
23 027	2182802	195759	NE NE	01/24/89	No	01/31/89	Yes	--	Yes	02/23/89
23 034	2180902	191258		11/30/88	Yes	--	-	--	Yes	12/05/88
23 035	2180891	191258		11/30/88	Yes	--	-	--	Yes	12/07/88
23 041	2181479	195948	NE NW	01/24/89	No	--	-	02/03/89	-	-
23 042	2181964	195952	NW NE	01/24/89	No	02/10/89	No	02/14/89	-	-
23 054	2180938	191518		11/30/88	Yes	--	-	--	Yes	12/14/88
23 056	2181625	191448		11/30/88	Yes	--	-	--	Yes	12/21/88
23 060	2180246	194465	SE NW	11/21/88	Yes	--	-	--	Yes	11/23/88

TABLE 2-2

CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
23 062	2179813	194715	SE NW	--	-	--	-	--	-	T-37
23 065	2178946	195213	NW NW	11/21/88	Yes	--	-	--	Yes	11/28/88
23 112	2182633	195978	NE NE	01/24/89	No	--	-	02/03/89	-	-
23 113	2182633	195878	NE NE	01/24/89	No	02/13/89	Yes	--	Yes	02/22/89
23 114	2182978	195980	NE NE	01/24/89	No	--	-	02/03/89	-	-
23 115	2182978	195880	NE NE	01/24/89	No	02/15/89	Yes	--	Yes	02/21/89
23 116	2183323	195981	NE NE	01/24/89	No	--	-	02/03/89	-	-
23 117	2183323	195881	NE NE	01/24/89	No	02/14/89	Yes	--	Yes	02/20/89
23 145	2181766	195576		11/30/88	Yes	--	-	--	Yes	12/22/88
23 147	2181126	195592	NW NE	11/21/88	No	01/04/89	No	01/16/89	-	-
23 152	2182399	195678	NE NE	01/24/89	No	--	-	02/03/89	-	-
23 153	2182629	195678	NE NE	01/24/89	Yes	--	-	--	Yes	04/04/89
23 154	2182859	195679	NE NE	01/24/89	No	--	-	02/03/89	-	-
23 155	2183089	195680	NE NE	01/24/89	No	--	-	02/03/89	-	-
23 156	2183319	195681	NE NE	01/24/89	No	--	-	02/03/89	-	-
23 162	2182949	196199	NE NE	--	-	--	-	--	-	T-37
23 163	2181027	195956	NW NE	--	-	--	-	--	-	T-37
23 164	2181027	195948	NW NE	--	-	--	-	--	-	T-37
23 165	2182027	195959	NW NE	01/24/89	No	02/13/89	No	02/14/89	-	-
23 167	2181879	195967	NW NE	11/30/88	No	12/30/88	No	01/16/89	-	-
23 168	2181879	195967	NW NE	11/30/88	No	12/30/88	Yes	--	Yes	01/17/89
23 169	2181879	195967	NW NE	11/30/88	No	12/30/88	No	01/16/89	-	-
23 170	2182641	195867	NE NE	--	-	--	-	--	-	T-37
23 171	2183425	195900	NE NE	11/30/88	No	01/04/89	No	01/04/89	-	-
23 172	2182311	195890	NE NE	11/22/88	No	01/03/89	Yes	--	Yes	01/10/89
23 173	2182048	195896	NW NE	11/22/88	No	--	-	12/20/88	-	-
23 174	2181522	195687	NW NE	11/22/88	No	--	-	12/20/88	-	-
23 175	2181378	195377	NW NE	01/24/89	No	02/14/89	Yes	--	Yes	02/23/89
23 210	2182579	195312		11/30/88	Yes	--	-	--	-	-
23 336	2181941	195797		11/21/88	Yes	--	-	--	-	-
23 337	2182336	195879		11/21/88	Yes	--	-	--	Yes	04/20/89
23 338	2182536	195879		11/21/88	Yes	--	-	--	Yes	04/24/89
23 339	2182735	195880		11/21/88	Yes	--	-	--	Yes	04/26/89
23 340	2182945	195881		11/21/88	Yes	--	-	--	-	-
23 341	2183145	195882		11/21/88	Yes	--	-	--	-	-
23 342	2183335	195884		11/21/88	Yes	--	-	--	-	-
23 A01	2179666	191921	SE SW	11/21/88	Yes	--	-	--	-	-
23 A02	2179645	191939	SE SW	11/21/88	Yes	--	-	--	-	-
23 A03	-	-	NE SW	11/22/88	Yes	--	-	--	Yes	03/27/89
23 A04	2178561	196234	NW NW	--	-	--	-	--	-	T-37
23 A05	-	-	NE NW	11/21/88	Yes	--	-	--	-	COE

TABLE 2-2

CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
23 A06	-	-	NE NE	11/22/88	No	--	-	--	-	-
23 A07	-	-	SE NE	11/22/88	No	--	-	--	-	-
23 A08	2179623	191959	NW SW	11/21/88	Yes	--	-	--	-	-
** SECTION 24										
24 005	2185211	195977	NE NW	12/09/88	No	01/18/89	Yes	--	Yes	04/28/89
24 012	2183601	195965	NW NW	12/13/88	No	01/06/89	No	01/06/89	-	-
24 029	2186074	195987	NE NW	12/09/88	No	01/20/89	Yes	--	Yes	01/27/89
24 030	2186573	195993	NW NE	12/09/88	No	01/26/89	No	02/14/89	-	-
24 031	2187073	195999	NW NE	12/09/88	No	02/15/89	Yes	--	Yes	02/20/89
24 032	2187573	196005	NE NE	12/09/88	No	12/27/89	No	02/03/89	-	-
24 033	2186079	195987	NE NW	12/09/88	No	01/20/89	Yes	--	Yes	01/27/89
24 034	2186084	195987	NE NW	12/09/88	No	01/23/89	Yes	--	Yes	01/26/89
24 035	2186124	195988	NE NW	12/09/88	No	01/20/89	Yes	--	Yes	02/01/89
24 036	2186174	195988	NE NW	12/12/88	No	01/23/89	Yes	--	Yes	02/15/89
24 037	2186074	195982	NE NW	12/09/88	No	01/20/89	Yes	--	Yes	02/28/89
24 038	2186074	195977	NE NW	12/09/88	No	01/20/89	Yes	--	Yes	02/16/89
24 039	2186074	195937	NE NW	12/09/88	No	01/20/89	Yes	--	Yes	01/31/89
24 040	2186075	195887	NE NW	12/09/88	No	01/23/89	Yes	--	Yes	02/10/89
24 050	2184912	193636	NE SW	12/09/88	Yes	--	-	--	Yes	01/05/89
24 059	2185824	195984	NE NW	12/13/88	No	01/17/89	No	03/10/89	-	-
24 060	2185351	195980	NE NW	12/13/88	No	01/13/89	No	01/16/89	-	-
24 061	2185600	195982	NE NW	12/13/88	No	01/17/89	No	01/24/89	-	-
24 066	2186106	196410	NE NW	12/13/88	No	02/17/89	No	02/23/89	-	-
24 067	2185857	196409	NE NW	12/13/88	No	--	-	--	Yes	02/17/89
24 068	2185157	195974	NE NW	12/13/88	No	01/18/89	Yes	--	Yes	02/16/89
24 091	2184248	192446	SW SW	12/06/88	Yes	--	-	--	Yes	12/29/88
24 116	2185844	195168	SE NW	04/25/89	Yes	--	-	--	Yes	04/27/89
24 119	2183549	195682	NW NW	12/12/88	No	--	-	01/23/89	-	-
24 120	2188073	196011	NE NE	--	-	--	-	--	-	T-37
24 131	2184956	195967	NE NW	12/09/88	No	01/12/89	Yes	--	Yes	03/07/89
24 132	2184956	195967	NE NW	12/09/88	No	01/12/89	No	03/10/89	-	-
24 133	2184214	195974	NW NW	12/12/88	No	01/10/89	No	01/10/89	-	-
24 134	2184214	195974	NW NW	12/12/88	No	01/10/89	No	01/10/89	-	-
24 138	2183733	195933	NW NW	12/12/88	No	01/09/89	No	01/10/89	-	-
24 139	2183733	195933	NW NW	12/12/88	No	01/09/89	Yes	--	Yes	01/25/89
24 140	2185455	195931	NE NW	12/09/88	No	01/16/89	Yes	--	Yes	03/08/89
24 141	2185455	195931	NE NW	12/09/88	No	01/16/89	No	03/10/89	-	-
24 142	2185942	195927	NE NW	12/09/88	No	01/19/89	Yes	--	Yes	03/15/89
24 143	2185963	195927	NE NW	12/09/88	No	01/19/89	Yes	--	Yes	03/20/89
24 144	2186460	195863	NW NE	--	-	--	-	--	-	T-37

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CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
24 145	2186958	195990	NW NE	12/13/88	No	02/14/89	No	03/10/89	-	-
24 146	2186958	195990	NW NE	12/13/88	No	02/15/89	Yes	--	Yes	03/13/89
24 147	2187459	195998	NW NE	12/13/88	No	01/27/89	No	02/03/89	-	-
24 148	2186629	195710	NW NE	12/13/88	No	--	-	01/25/89	-	-
24 153	2184226	195698	NW NW	12/13/88	Yes	--	-	--	-	-
24 154	2186451	195924	NW NE	12/13/88	No	01/24/89	Yes	--	Yes	03/22/89
24 155	2186411	195911	NW NE	12/13/88	No	--	-	01/23/89	-	-
24 156	2186530	195899	NW NE	12/09/88	No	--	-	--	-	-
24 157	2186542	195934	NW NE	12/09/88	No	01/25/89	No	01/26/89	-	-
24 343	2183544	195884		12/09/88	Yes	--	-	--	-	-
24 344	2183745	195885		12/09/88	Yes	--	-	--	-	-
24 345	2183945	195886		12/09/88	Yes	--	-	--	-	-
24 346	2184145	195887		12/09/88	Yes	--	-	--	-	-
24 347	2185849	195895		12/09/88	Yes	--	-	--	-	-
24 348	2186049	195894		12/09/88	Yes	--	-	--	-	-
24 349	2186329	195896		12/09/88	Yes	--	-	--	-	-
24 350	2186529	195898		12/09/88	Yes	--	-	--	-	-
24 351	2186658	195899		12/09/88	Yes	--	-	--	-	-
24 352	2187018	195900		12/09/88	Yes	--	-	--	-	-
24 353	2187296	195881		12/09/88	Yes	--	-	--	-	-
24 354	2187497	195882		12/09/88	Yes	--	-	--	-	-
24 A01	-	-	SE SE	12/02/88	No	--	-	--	-	-
24 A02	2188634	195488	NE SE	12/13/88	Yes	--	-	--	Yes	04/12/89
24 A03	2185977	196310	NW NE	12/02/88	Yes	--	-	--	Yes	03/03/89
24 A04	-	-	NE SW	12/02/88	No	02/15/89	Yes	--	Yes	03/06/89
24 A05	2184850	193821	NE SW	12/02/88	No	02/15/89	Yes	--	-	-
24 A06	2183892	193848	NW SW	12/02/88	Yes	--	-	--	-	-
** SECTION 25										
25 002	2184067	185922	SW SW	03/27/89	Yes	--	-	--	Yes	04/17/89
25 005	2183685	190245	NW SW	02/15/89	Yes	--	-	--	-	-
25 006	2183685	190245	NW SW	02/15/89	Yes	--	-	--	-	-
25 A01	-	-	NE NW	02/15/89	No	--	-	--	-	-
25 A02	-	-	NE NW	02/15/89	No	--	-	--	-	-
25 A03	-	-	NW NE	02/15/89	No	--	-	--	-	-
** SECTION 26										
26 007	2181611	189714	SW NE	02/07/89	No	--	-	--	-	-
26 008	2180824	190424		--	-	--	-	--	-	-
26 012	2181771	188460	NW SE	02/07/89	No	--	-	--	-	-
26 013	2181232	189754		02/07/89	No	--	-	--	-	-

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CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
26 021	2179311	189703		--	-	--	-	--	-	-
26 030	2181694	188146		--	-	--	-	--	-	-
26 031	2181753	188324	NW SE	02/07/89	No	--	-	--	-	-
26 032	2181726	188535	NW SE	02/07/89	No	--	-	--	-	-
26 033	2181679	188932	SW NE	02/07/89	No	--	-	--	-	-
26 034	2181534	189300	SW NE	02/07/89	No	--	-	--	-	-
26 035	2181371	189662	SW NE	02/07/89	No	--	-	--	-	-
26 036	2181287	189842	SW NE	02/07/89	No	--	-	--	-	-
26 037	2181172	190004	NW NE	02/07/89	No	--	-	--	-	-
26 038	2181042	190171	NW NE	02/07/89	No	--	-	--	-	-
26 039	2180924	190328	NW NE	02/07/89	No	--	-	--	-	-
26 042	2180845	190623	NE NW	02/07/89	No	--	-	--	-	-
26 043	2180855	190723		--	-	--	-	--	-	T-37
26 044	2180886	191021		--	-	--	-	--	-	T-37
26 046	2181194	190897		--	-	--	-	--	-	T-37
26 052	2182061	188260		02/07/89	No	03/16/89	Yes	--	Yes	03/27/89
26 053	2180928	187523		02/07/89	No	03/16/89	Yes	--	Yes	04/19/89
26 054	2182743	187183		02/07/89	Yes	--	-	--	Yes	03/29/89
26 098	2183059	186116	SE SE	01/04/89	Yes	--	-	--	-	-
26 119	2181218	188372		02/07/89	No	--	-	--	-	-
26 125	2180321	190653		02/07/89	No	--	-	--	-	-
26 126	2179299	190097		02/07/89	Yes	--	-	--	-	-
26 131	2181714	188634		02/07/89	No	--	-	--	-	-
26 137	2179058	190172	NW NW	01/04/89	Yes	--	-	--	-	-
26 138	2181128	190463		--	-	--	-	--	-	-
26 139	2181128	190463		--	-	--	-	--	-	-
26 A01	2178661	188337	SW NW	--	-	--	-	--	-	T-37
26 A02	-	-	NE NW	--	-	--	-	--	-	-
26 A03	2181183	189907	NW NE	--	-	--	-	--	-	T-37
** SECTION 27										
27 001	2173573	190790	NW NW	--	-	--	-	--	-	-
27 014	2178077	190522	NE NE	01/25/89	Yes	--	-	--	-	T-37
27 021	2177815	188792	SE NE	01/25/89	Yes	--	-	--	-	T-37
27 022	2177778	188545	SE NE	01/25/89	Yes	--	-	--	-	T-37
27 023	2177741	188300	NE SE	01/25/89	Yes	--	-	--	-	T-37
27 050	2177770	187003		01/25/89	Yes	--	-	--	-	-
27 052	2176604	185887		01/25/89	No	04/14/89	No	--	-	-
27 067	2175250	190404	NE NW	01/25/89	Yes	--	-	--	Yes	04/07/89
27 A01	-	-	NE NW	--	-	--	-	--	-	COE
27 A02	-	-	NW NW	--	-	--	-	--	-	COE

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(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
27 A03	-	-	NW NW	01/26/89	No	--	-	--	-	-
27 A04	-	-	NW NW	01/26/89	Yes	--	-	--	Yes	04/27/89
27 A05	2177968	186544	SE SE	01/25/89	Yes	--	-	--	-	T-37
27 A06	2173272	188702	SW NW	01/25/89	Yes	--	-	--	-	-
** SECTION 28										
28 001	2173000	189536		04/26/89	No	04/28/89	No	--	-	-
28 010	2171517	187844	SW NE	04/26/89	Yes	--	-	--	-	-
28 015	2170693	186905		04/26/89	Yes	--	-	--	-	-
28 016	2170528	186717	NW SE	04/26/89	Yes	--	-	--	-	-
28 017	2170363	186529	NW SE	--	-	--	-	--	-	-
28 019	2170034	186153	NE SW	04/26/89	Yes	--	-	--	-	-
28 A01	-	-	SE NE	02/17/89	Yes	--	-	--	-	-
28 A02	-	-	NE SE	02/17/89	No	--	-	--	-	-
** SECTION 30										
30 012	-	-		--	-	--	-	--	-	-
30 013	-	-		--	-	--	-	--	-	-
30 014	-	-		--	-	--	-	--	-	-
30 015	-	-		--	-	--	-	--	-	-
30 016	-	-		--	-	--	-	--	-	-
30 017	-	-		--	-	--	-	--	-	-
30 A01	2188970	187291	NW SW	03/29/89	Yes	--	-	--	-	-
30 A02	-	-	SW SW	03/31/89	No	04/04/89	No	--	-	-
30 A03	2189364	186568	SW SW	03/29/89	No	04/04/89	Yes	--	-	-
30 A04	-	-		03/29/89	Yes	--	-	--	-	-
30 A05	-	-		03/29/89	Yes	--	-	--	-	-
30 A06	-	-	NW SW	03/31/89	No	--	-	--	-	-
** SECTION 31										
31 001	2191206	184625	NE NW	--	-	--	-	--	-	-
31 004	2189452	180968	SW SW	04/26/89	Yes	--	-	--	-	-
31 A01	-	-	SW SW	03/31/89	No	--	-	--	-	-
31 A02	2189449	184852	NW NW	03/31/89	Yes	--	-	--	Yes	04/13/89
31 A03	-	-	NW NW	03/31/89	No	--	-	--	-	-
31 A04	2189249	185426	NW NW	03/31/89	Yes	--	-	--	-	-
31 A05	-	-	SE SE	--	-	--	-	--	-	-
31 A06	-	-	SE SE	--	-	--	-	--	-	-
31 A07	-	-	SE SE	--	-	--	-	--	-	-
31 A08	2191579	180774	SW SE	03/31/89	Yes	--	-	--	Yes	04/18/89
31 A09	-	-	NW NW	03/31/89	No	--	-	--	-	-

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CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
** SECTION 32										
32 A01	-	-		03/30/89	No	04/11/89	No	--	-	-
32 A02	-	-		03/30/89	Yes	--	-	--	-	-
32 A03	-	-		03/30/89	Yes	--	-	--	-	-
32 A04	-	-		03/30/89	No	04/14/89	No	--	-	-
32 A05	-	-		03/30/89	No	--	-	--	-	-
32 A06	-	-		03/30/89	No	04/11/89	No	--	-	-
** SECTION 33										
33 003	2169540	185589	NE NW	04/27/89	Yes	--	-	--	-	-
33 004	2169375	185401	NE NW	04/27/89	Yes	--	-	--	-	-
33 005	2169210	185214	NE NW	04/27/89	Yes	--	-	--	-	-
33 006	2169045	185026	NE NW	04/27/89	Yes	--	-	--	-	-
33 007	2168881	184838	NE NW	04/27/89	Yes	--	-	--	-	-
33 008	2168716	184650	NE NW	04/27/89	Yes	--	-	--	-	-
33 009	2168551	184462	NE NW	04/27/89	Yes	--	-	--	-	-
33 010	2168386	184274	NE NW	04/27/89	Yes	--	-	--	-	-
33 011	2168366	184025	NE NW	04/27/89	Yes	--	-	--	-	-
33 012	2168345	183776	NE NW	--	-	--	-	--	-	T-37
33 013	2168324	183527	NE NW	--	-	--	-	--	-	T-37
33 016	2168211	182301		--	-	--	-	--	-	T-37
33 A01	2168694	185202	NE NW	--	-	--	-	--	-	T-37
33 A02	2169182	185378	NE NW	02/08/89	No	--	-	--	-	-
33 A03	2171062	180669	SE SE	02/08/89	No	--	-	--	-	-
33 A04	2171062	180669	SW SE	--	-	--	-	--	-	T-37
33 A05	-	-	SE SW	02/08/89	No	--	-	--	-	-
33 A06	2168805	180900	SE SW	02/08/89	Yes	--	-	--	Yes	03/21/89
33 A07	-	-	SW NW	02/08/89	No	--	-	--	-	-
33 A08	2167877	184284	SW NW	02/08/89	Yes	--	-	--	Yes	03/24/89
33 A09	2168239	184203	NW NW	02/07/89	Yes	--	-	--	Yes	03/17/89
33 A10	2168340	184130	SW NW	02/07/89	Yes	--	-	--	Yes	03/14/89
33 A11	2168424	184051	SW NW	02/07/89	Yes	--	-	--	Yes	03/09/89
** SECTION 34										
34 001	2177422	185095	NE NE	01/27/89	Yes	--	-	--	Yes	04/03/89
34 A01	2173131	181886	SW SW	01/27/89	Yes	--	-	--	Yes	03/22/89
** SECTION 35										
35 001	2183002	184146	SE NE	04/28/89	Yes	--	-	--	-	-
35 002	2183373	184376		01/26/89	Yes	--	-	--	Yes	04/11/89

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CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
35 004	2179622	185284	NW NW	04/28/89	Yes	--	-	--	-	-
35 005	2179538	184669		01/26/89	Yes	--	-	--	Yes	04/14/89
35 006	2179616	181792		04/28/89	Yes	--	-	--	-	-
35 010	2181817	185699	NW NE	--	-	--	-	--	-	T-37
35 019	2181896	185826	NW NE	--	-	--	-	--	-	T-37
35 024	2183527	182723	NE SE	--	-	--	-	--	-	T-37
35 042	2178561	184632	SW NW	04/28/89	Yes	--	-	--	-	-
35 043	2179706	184166	SE NW	04/28/89	Yes	--	-	--	-	-
35 044	2182026	184984	NW NE	04/28/89	Yes	--	-	--	-	-
35 045	2182396	184499	SE NE	04/28/89	Yes	--	-	--	-	-
35 046	2182380	185371	NE NE	04/28/89	Yes	--	-	--	-	-
35 049	2179706	184166	SE NW	--	-	--	-	--	-	T-37
35 A01	-	-	SW NW	01/26/89	No	--	-	--	-	COE
35 A02	2179606	184937	NW NW	01/26/89	Yes	--	-	--	Yes	03/27/89
35 A03	2183452	185841	NE NE	01/26/89	Yes	--	-	--	-	-
35 A04	2183407	185834	NE NE	01/26/89	Yes	--	-	--	-	COE
35 AGM1	2183459	185789	NE NE	01/26/89	Yes	--	-	--	-	-
** SECTION 36										
36 002	2183877	185117	NW NW	04/28/89	Yes	--	-	--	-	-
36 002b	2183877	185117	NW NW	04/28/89	Yes	--	-	--	-	-
36 003	2184127	185118		04/28/89	Yes	--	-	--	-	-
36 003b	2184127	185118		04/28/89	Yes	--	-	--	-	-
36 004	2184377	185120		02/28/89	Yes	--	-	--	-	-
36 006	2184628	184871		02/28/89	Yes	--	-	--	-	-
36 007	2184378	184870		04/28/89	Yes	--	-	--	-	-
36 007b	2184378	184870		04/28/89	Yes	--	-	--	-	-
36 008	2184128	184868		04/28/89	Yes	--	-	--	-	-
36 008b	2184128	184868		04/28/89	Yes	--	-	--	-	-
36 009	2183878	184867		04/28/89	Yes	--	-	--	-	-
36 009b	2183878	184867		04/28/89	Yes	--	-	--	-	-
36 011	2184130	184618		04/28/89	Yes	--	-	--	-	-
36 011b	2184130	184618		04/28/89	Yes	--	-	--	-	-
36 012	2184380	184620	NW NW	04/28/89	Yes	--	-	--	-	-
36 012b	3184380	184620	NW NW	04/28/89	Yes	--	-	--	-	-
36 014	2184631	184372		04/25/89	Yes	--	-	--	-	-
36 014b	2184631	184372		04/25/89	Yes	--	-	--	-	-
36 015	2184381	184370		04/28/89	Yes	--	-	--	-	-
36 015b	2184381	184370		04/28/89	Yes	--	-	--	-	-
36 016	2184131	184368		04/28/89	Yes	--	-	--	-	-
36 016b	2184131	184368		04/28/89	Yes	--	-	--	-	-

TABLE 2-2

CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
36 018	2184355	185076		04/28/89	Yes	--	-	--	-	-
36 018b	2184355	185076		04/28/89	Yes	--	-	--	-	-
36 020	2185094	183529		04/28/89	Yes	--	-	--	-	-
36 021	2183881	184417		--	-	--	-	--	-	-
36 022	2184231	184319		04/28/89	Yes	--	-	--	-	-
36 023	2184431	184370		04/28/89	Yes	--	-	--	-	-
36 025	2183780	184666		04/28/89	Yes	--	-	--	-	-
36 025b	2183780	184666		04/28/89	Yes	--	-	--	-	-
36 026	2184129	184718		04/28/89	Yes	--	-	--	-	-
36 026b	2184129	184718		04/28/89	Yes	--	-	--	-	-
36 027	2184430	184670		04/28/89	Yes	--	-	--	-	-
36 027b	2184430	184670		04/28/89	Yes	--	-	--	-	-
36 033	2183877	185067		04/28/89	Yes	--	-	--	-	-
36 033b	2183877	185067		04/28/89	Yes	--	-	--	-	-
36 034	2184127	185018		04/28/89	Yes	--	-	--	-	-
36 034b	2184127	185018		04/28/89	Yes	--	-	--	-	-
36 037	2183893	182617	NW SW	04/20/89	Yes	--	-	--	-	-
36 037b	2183893	182617	NW SW	04/20/89	Yes	--	-	--	-	-
36 038	2183891	182867	NW SW	04/20/89	Yes	--	-	--	Yes	04/27/89
36 038b	2183891	182867	NW SW	04/20/89	Yes	--	-	--	Yes	04/27/89
36 039	2183889	183117	NW SW	04/20/89	Yes	--	-	--	Yes	04/25/89
36 040	2184644	182372	NW SW	--	-	--	-	--	-	-
36 040b	2184644	182372	NW SW	--	-	--	-	--	-	-
36 041	2184642	182622	NW SW	--	-	--	-	--	-	-
36 041b	2184642	182622	NW SW	--	-	--	-	--	-	-
36 042	2184641	182872	NW SW	--	-	--	-	--	-	-
36 042b	2184641	182872	NW SW	--	-	--	-	--	-	-
36 044	2183900	181368	SW SW	04/20/89	Yes	--	-	--	-	-
36 044b	2183900	181368	SW SW	04/20/89	Yes	--	-	--	-	-
36 045	2183899	181618	SW SW	04/20/89	Yes	--	-	--	-	-
36 045b	2183899	181618	SW SW	04/20/89	Yes	--	-	--	-	-
36 046	2183897	181868	SW SW	04/20/89	Yes	--	-	--	-	-
36 046b	2183897	181868	SW SW	04/20/89	Yes	--	-	--	-	-
36 047	2183896	182117		04/20/89	Yes	--	-	--	-	-
36 047b	2183896	182117		04/20/89	Yes	--	-	--	-	-
36 048	2183900	181123		--	-	--	-	--	-	-
36 049	2183902	180873	SW SW	--	-	--	-	--	-	-
36 053	2184655	180623	SW SW	--	-	--	-	--	-	-
36 055	2184650	181372		--	-	--	-	--	-	-
36 055b	2184650	181372		--	-	--	-	--	-	-
36 070	2184911	182848	NE SW	--	-	--	-	--	-	-

TABLE 2-2

CLOSURE STATUS OF WELLS APPROVED FOR CLOSURE BY PMRMA
(INCLUDING TASK 37 WELLS)

WELL NUMBER	STATE EASTING COORD.	STATE NORTHING COORD.	QUAD.	FIRST SEARCH DATE	WELL FOUND ?	SECOND SEARCH DATE	WELL FOUND ?	SEARCH CANCEL DATE	WELL CLOSED IRA-3	CLOSURE DATE OF WELL
36 071	2184911	182848	NE SW	--	-	--	-	--	-	-
36 091	2188187	183181		--	-	--	-	--	-	-
36 095	2184386	183620		04/28/89	Yes	--	-	--	-	-
36 096	2184636	183622		04/28/89	Yes	--	-	--	-	-
36 097	2184135	183869		04/25/89	Yes	--	-	--	-	-
36 098	2184385	183870		04/28/89	Yes	--	-	--	-	-
36 100	2184383	184120		04/28/89	Yes	--	-	--	-	-
36 101	2184638	183372	SW NW	04/28/89	Yes	--	-	--	-	-
36 102	2183885	183867	SW NW	04/20/89	Yes	--	-	--	-	-
36 103	2185633	181513		--	-	--	-	--	-	-
36 106	2183686	184558	NW NW	04/28/89	Yes	--	-	--	-	-
36 107	2183703	185615		04/28/89	Yes	--	-	--	-	-
36 A01	-	-	SW SE	--	-	--	-	--	-	-
36 A02	-	-	NE NE	--	-	--	-	--	-	-

This information will be electronically transferred into the new database, and then supplemented by:

- o Information derived by technically reviewing all available hardcopy records of these wells, available from RMA and other sources;
- o Information derived from the field searches to be conducted for these wells; and
- o Information to be compiled during the closure of some of these wells.

The Task IRA-3 database will be used as an information source during the well closure decision process, during scheduling of Task IRA-3 field activities, and as a source of historical well information. The Task IRA-3 database will be updated continually as new data become available to provide a computerized tool for determining well status and refining resource needs for well closure.

2.2 LOCATION OF ABANDONED WELLS

During Task IRA-3 the procedures for locating and closing wells will be very similar to those employed during Task 37. Gradiometer and magnetometer methods (Sections 2.2.2.1 and 2.2.2.2) will be employed in first and second level searches for exploring reported well locations. If the search methods employed fail to find a well, the well will be classified as "non-existent", and no further efforts will be made to discover its existence or location. Information collected from wells located in the field will be input to the Task IRA-3 database and used to plan closure activities.

2.2.1 Wells Already Located

Table 2-2 provides a detailed breakdown of the status (found, not found, etc.) of wells identified under Task 37 for potential closure. This information was derived from the Task 37 report and databases. Table 2-2 also includes the 15 post-1942 wells which have been field located by the Army in Section 9 and which are identified for closure consideration due to their location.

A total of 82 wells were found during first and second level field searches under Task 37. Of these, only 39 wells were closed. The remaining 43 wells found during Task 37 will be evaluated for closure during Task IRA-3.

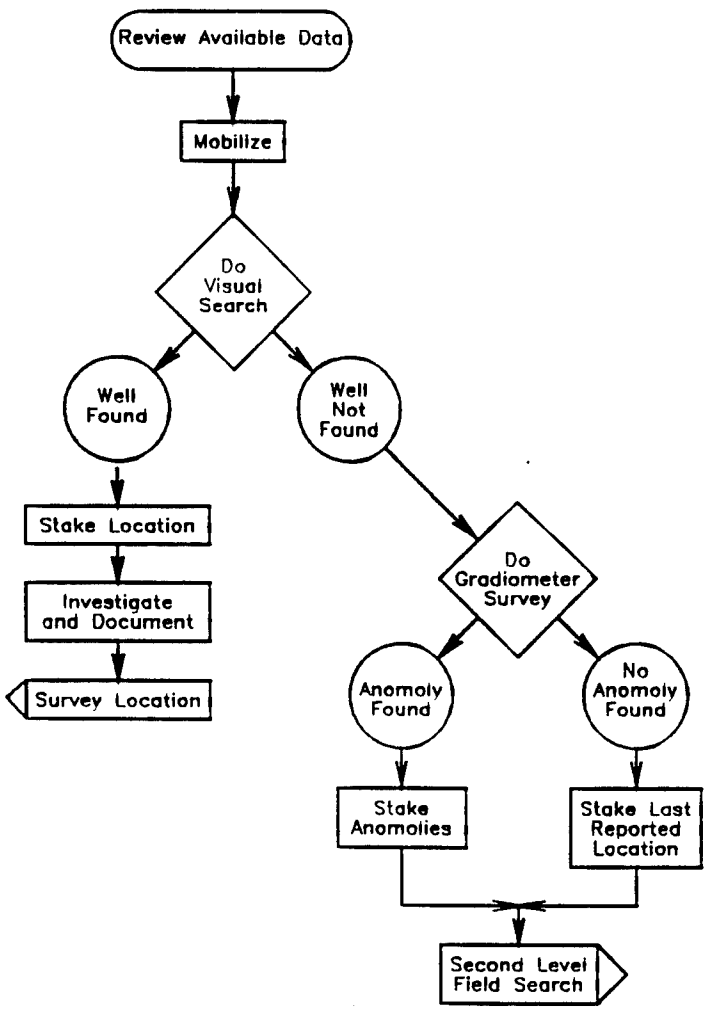
2.2.2 Wells To Be Located

A two-tiered search program to determine the physical location, characteristics, and conditions of wells not yet found, will begin with a review of the well database, derived from computerized and hardcopy sources. The two-tier search program is described in the following sections.

2.2.2.1 First Level Field Search

All wells identified for potential closure (Table 2-2), but not yet located will be subjected to a first level field search. This will entail making a detailed visual inspection of the reported location of the well, and if not found by this effort, making a detailed sweep of the suspected area with a hand-held gradiometer. Wells which are found by visual inspection will be staked for subsequent location surveying, while areas of anomalous gradiometer readings will be staked for future investigation during a second level field search. Any wells found visually during the first level field search will be initially assessed for their immediately determinable characteristics (i.e., diameter, open depth, etc.) and current physical condition (i.e., rusty, obstructed, etc.). All such information will be entered into the Task IRA-3 database to update the known information about these wells. A graphical description of the sequence of first level field search activities is presented on Figure 2-3.

FIRST LEVEL FIELD SEARCH
TASK IRA-3 FIGURE 2-3



2.2.2.2 Second Level Field Search

Wells which are not visually located during the first level field search will be the subject of a second level field search. A second level field search will consist of excavation of suspected areas yielding gradiometer anomalies (in first level field search) and/or detailed magnetometer surveys (on a 10'x10' grid pattern in up to a 300'by 300' area) in the suspected area, followed by excavation of areas of observed magnetic anomalies. If these methods are unsuccessful in locating a well, any apparent magnetic source will be noted. No further search efforts to locate the well will be performed, and the reported well information and status will be recorded in the Task IRA-3 database. For buried wells which are located during the second level field search, the buried wellhead will be extended to the ground surface and the well will be staked for future survey of its location and elevation. Further, initial assessment of its readily-determinable characteristics and condition will be performed and documented in the database. A graphical description of the sequence of activities to be performed during the second level field search is presented in Figure 2-4.

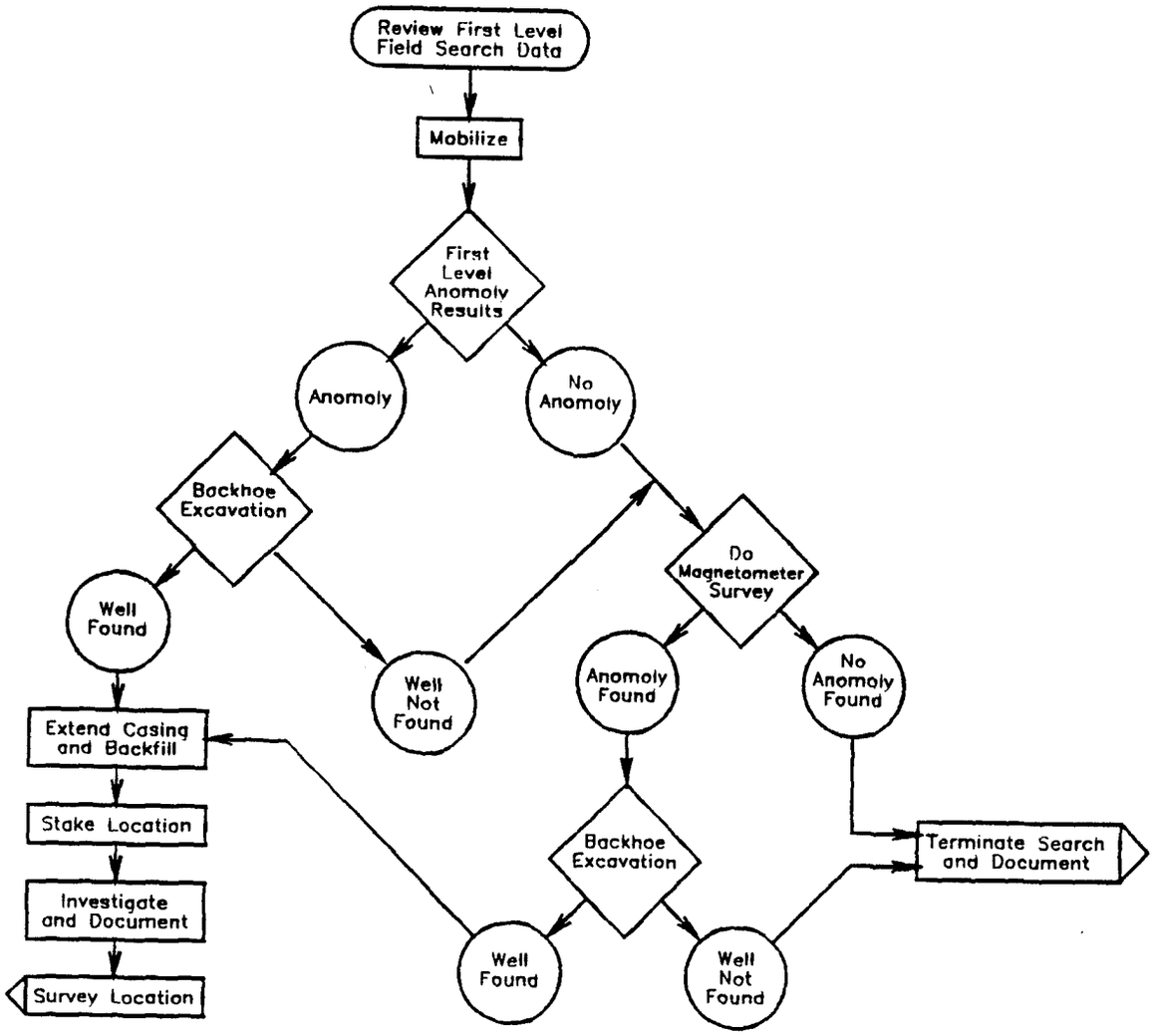
2.2.3 Finalization of Well Closure Inventory

The final well closure inventory will consist of those wells from the initial well databases which are found during the first and second level field searches and are approved for closure by PMRMA. No well will be closed without prior approval of PMRMA.

2.2.4 Water Sampling Criteria

Following the collection of available field data for each well, and prior to any well closure activities, a decision will be made regarding whether or not water quality

SECOND LEVEL FIELD SEARCH
TASK IRA-3 FIGURE 2-4



sampling should be performed prior to closure. The policy to be followed in this decision making will be:

1. Do not sample wells with unknown or incompletely known critical well construction details (i.e., how/where the well is screened, sealed, etc.);

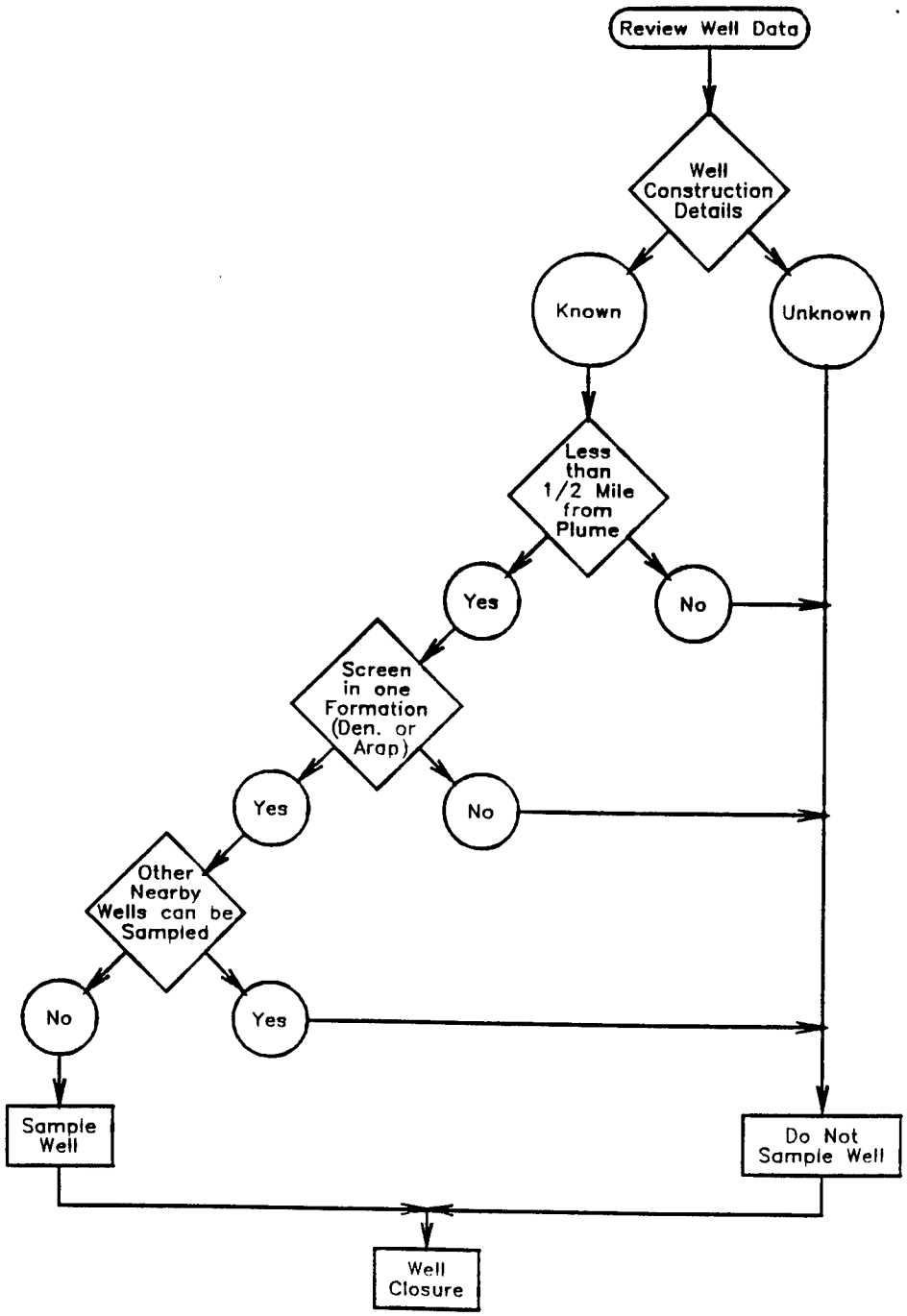
2. Sample wells which are within or up to one-half mile from known contaminant plumes;

3. Do not sample wells unless they are clearly and solely screened in the Denver or Arapahoe Formations; and

4. Do not sample wells which are near enough to existing monitoring wells in these formations which can be used effectively for monitoring purposes.

In following the above principles, the collection of redundant or extraneous water quality data will be minimized. The logic for making these determinations is presented graphically in Figure 2-5. The field geologist will be responsible for determining when a water sample should be collected. All water quality sampling operations will be performed in accordance with the procedures described in Section 6 of this Task Plan. Chemical analysis of the water quality samples extracted from the wells will be performed as described in Section 5 of this Task Plan.

WELL SAMPLING DIAGRAM
TASK IRA-3 FIGURE 2-5



SECTION 3

WELL CLOSURE PROGRAM

3.1 INTRODUCTION

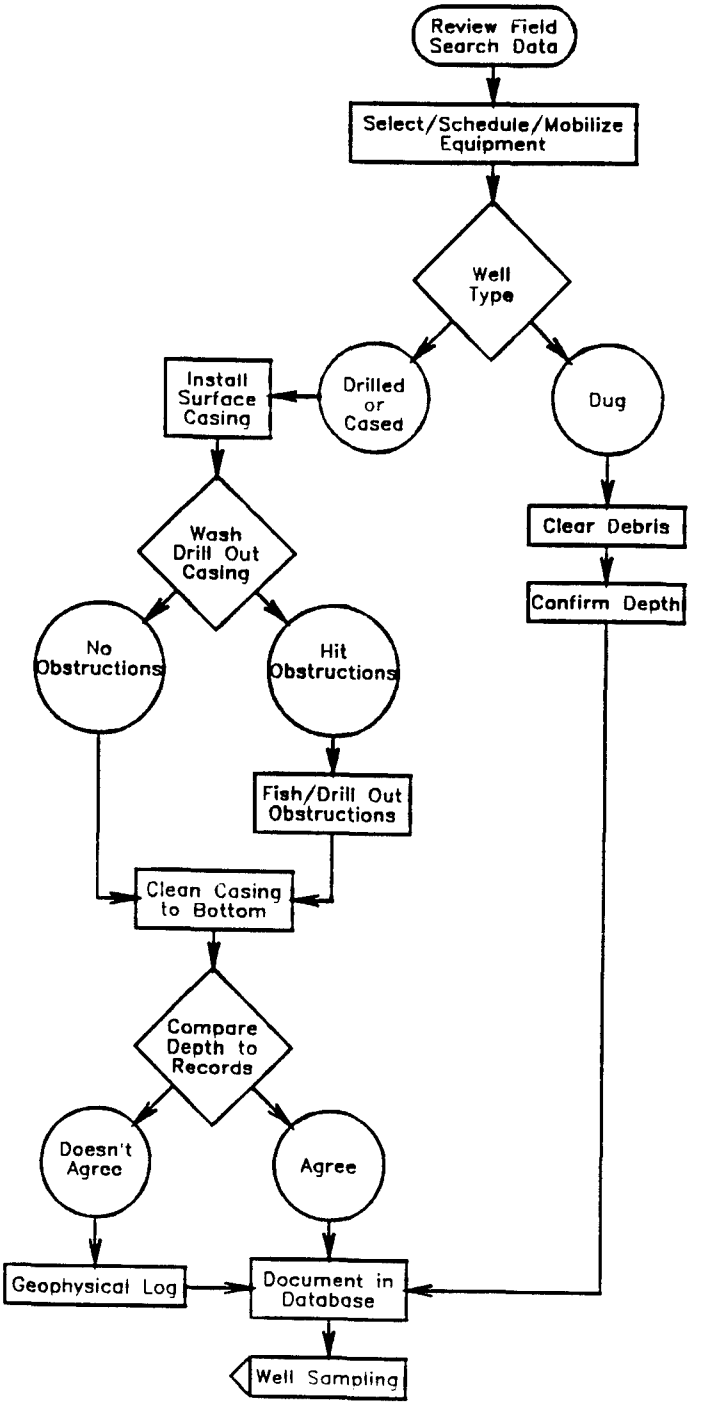
The well closure program shall commence upon approval by PMRMA of the initial well closure inventory (Table 2-1) and field location of the abandoned wells in each section. The tasks included in the well closure program will include cleaning each well, verifying the total depth and other necessary information on the well, and closing of the well. Groundwater sampling will be performed on those wells for which the groundwater sampling criteria (Section 2.2.4) are met.

3.2 WELL CLEANING AND DATA COLLECTION

The procedures to be followed during well closure are dependent on the type, construction, diameter, and depth of each well. For this reason, the collection and field verification of accurate well construction details is of critical importance. In order to conduct efficient well cleaning/well closure activities, the drill rig used for the cleaning of a well will also perform the closure activities where closure is appropriate. This system will expedite the well cleaning and closure sequence by eliminating the mobilization of multiple drill rigs to the same work location. However, adverse or changing field conditions may result in the modification of drill rig schedules. In these cases, different rigs may have to be employed to clean and close particular wells.

Figure 3-1 illustrates the steps involved in the well inspection and cleaning procedure. As shown, those wells which are open or that may be cleaned by circulating

WELL INSPECTION AND CLEANING
TASK IRA-3 FIGURE 3-1



water through the well to remove accumulated sediment or debris will be sounded to determine total depth. This information will be checked against existing records to verify construction details. If necessary, geophysical or caliper logging of the well will be conducted to collect information.

In some cases, it will be necessary to remove debris from, or redrill a well to clear obstructions. Caliper logging, geophysical logging, and/or a video survey of these wells may be necessary to determine the diameter of the borehole, to detail open borehole or screened intervals, and to establish the position of the casing and the depth of the well. If a well is found to be filled with cement or grout, an additional record search will be conducted in an attempt to document the previous closure. If no records are available the well will be redrilled and regrouted in order to verify proper closure.

3.3 CLOSURE PROGRAM

Closure methods employed during the program will be standard procedures commonly used in the water well and/or petroleum industries. All closures will be performed in compliance with the requirements of the State of Colorado (State Board of Examiners of Water Well Construction and Pump Installation Contractors, 1987) and of the Final Decision Document (1988). In the event that site or well conditions necessitate procedures which differ from those described in this task plan, PMRMA will be consulted prior to actual closure. Each well closure will be planned taking into account the borehole diameter, depth, hole deviation, formation properties, and casing condition.

Each well to be closed will be evaluated as a separate entity, with careful consideration given to the construction of the well and the geologic setting. Standardized closure will be adapted for each individual well to compensate for depth and volume of grout required to eliminate the vertical movement of water within the annular space and the well bore. If artesian conditions exist, the sealing operation will be designed to

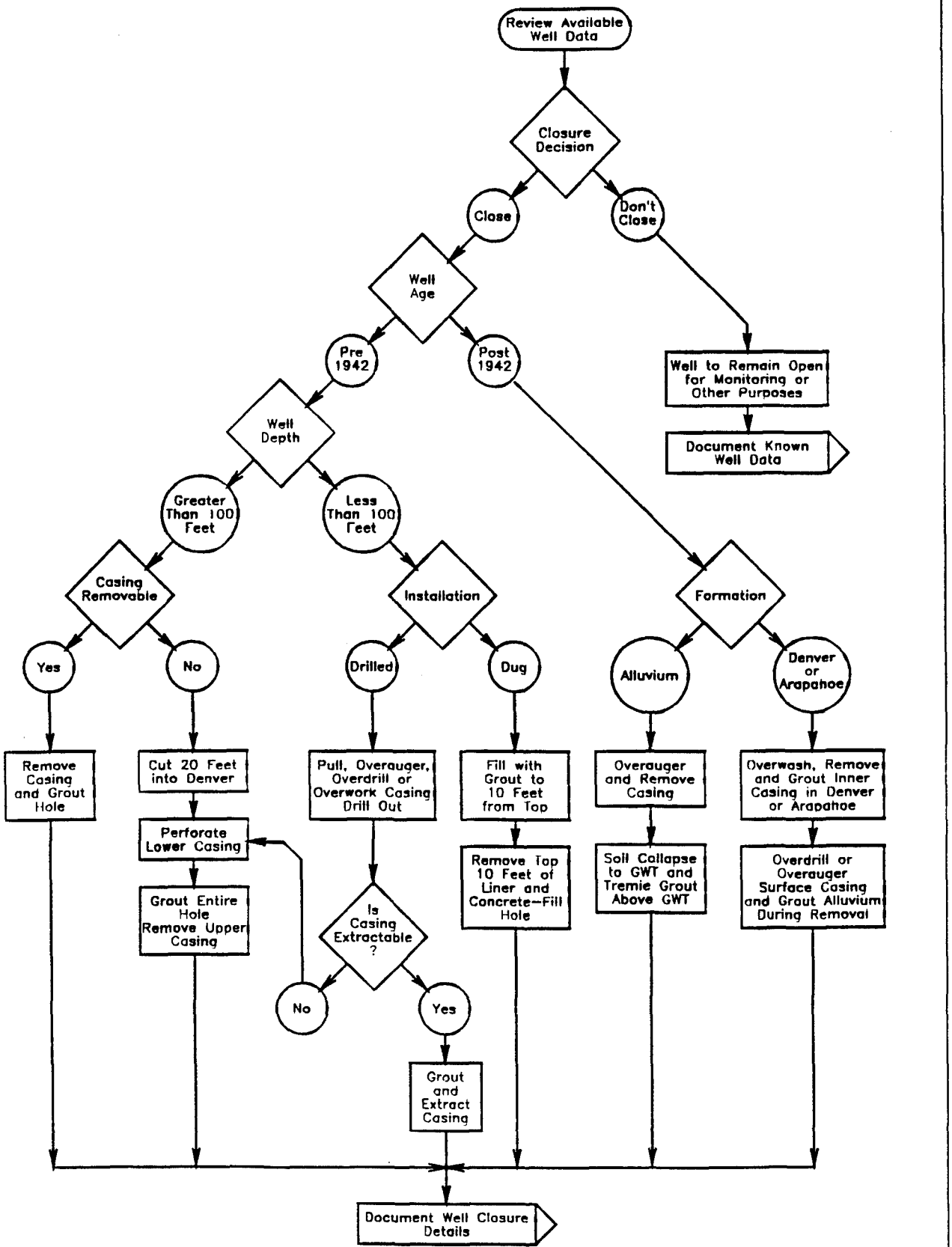
confine the water and prevent loss of artesian pressure or transfer of groundwater between aquifers.

Standard closure practices will include removal, to the extent possible, of all materials which would hinder the sealing operation, including screen and casing (Figure 3-2). If the casing cannot be removed, it may have to be cut, torn, or perforated to allow the grout to completely seal the annular space. This may be accomplished through the use of a perforating tool, a casing knife, or explosives.

Well closure will proceed following inspection of the borehole to ascertain casing and borehole conditions. If the casing appears to be in good condition, an attempt will be made to remove it while grout is being placed. If the casing appears to be in poor shape, no attempt will be made to recover it, as this could cause the hole to collapse and prevent proper closure.

Grout will be pumped to the bottom of the interval to be sealed through a tremie pipe and placed progressively upward to the top of the well. Grout will be pumped into the well until it flows undiluted from the well at ground surface. When conditions permit, grout placement and casing removal will be done concurrently to maintain 10 feet of grout within the casing as it is pulled. Grout composition will be determined based on hole conditions, additives, volume, and setting time desired. Water of drinking water quality will be used for mixing grout.

STANDARD WELL CLOSURE
TASK IRA-3 FIGURE 3-2



3.3.1 Pre-1942 Large-Diameter Hand Dug Wells

Hand dug wells with diameters of 24 to 60 inches and depths of 30 to 50 feet are typically constructed with cement, stone, or brick liners. These types of wells will be closed by filling the well with sand to within 10 feet of the surface followed by capping with commercial concrete. Those wells found to have been drilled through their bottom will be closed as drilled wells followed by closure of the upper dug portion, as described above.

3.3.2 Pre-1942 Drilled Wells

Closure of pre-1942 drilled wells will be based on a review of any available information on well construction. For wells that have contradictory or incomplete well construction records, information on the original total depth and design of each well will be developed during the cleaning out or redrilling of the wells and from limited use of borehole geophysical techniques. To properly close these wells an attempt will be made to remove the casing prior to grouting the borehole. The techniques used to accomplish this will depend upon the type and condition of the casing, but will include drilling and washing out debris found in the well, pulling the casing, and overdrilling the casing. If the casing cannot be removed, it will be perforated or cut and grouted in place.

3.3.3 Shallow Post-1942 Monitoring Wells

Many of these wells are constructed of PVC or steel casings (2 to 6 inches in diameter) with short screened intervals set opposite water-bearing portions of the alluvial materials or the Denver Formation. If the initial information about a well indicates that the well was not grouted in place, an effort will be made to pull the casing and screen. If this is not possible, an attempt to overdrill the well will be considered. In the event that

overdrilling of the well is not practical, the borehole will be cut or perforated and the casing grouted in place.

In most cases, it is expected that the records and field inspection will show that the well casing was cemented in place and that no pulling or salvaging of the casing and screen is possible. In this case, the screened portion of the well will be backfilled with clean sand and the remainder of the borehole will be filled with grout to the ground surface. If the depth of the well and the location of the screened interval are such that there is a possibility that the screen extends across more than one aquifer, the entire casing and screened interval will be filled with grout to the ground surface.

3.4 WELLS IDENTIFIED FOR CLOSURE PRIOR TO APPROVAL OF TASK PLAN

The Army intends to concentrate initially on closure of those wells located in Section 23 and 24. These sections have been identified as a priority due to their proximity to the property boundary and the North Boundary Containment System. These sections are also those which contain the largest number of wells for potential closure. Closure activities will begin with the shallow wells. Upon the completion of the closure of these shallow wells, closure activities for the deeper wells will be initiated.

3.5 PHASING OF FIELD ACTIVITIES

As indicated above, the Army intends to concentrate initially on closure of wells located in Section 23 and 24. Subsequent activities will be phased to allow for efficient utilization of resources and will include the following considerations:

- The Army intends to initiate field searching and closure activities in sections which contain large numbers of abandoned wells in order to build a backlog of wells to be closed and allow several drill rigs to be mobilized.
- Well closure activities will be grouped, as possible, to minimize distance between crews and allow for efficient oversight by Army geologists and health and safety personnel.

- o Closure activities in the wildlife management areas will be planned for summer and fall so as to minimize potential wildlife related delays.

The development of a backlog of wells to be closed will allow each drill rig to go directly from one well to another with no downtime. As new wells are located, the backlog for each drill rig will be updated. Assignment of a well to a particular rig will be based on the depth and diameter of each well and the closure technique anticipated for use.

3.6 SUPPORT ACTIVITIES

3.6.1 Topographic Surveys

Wells located during IRA-3 will be surveyed to establish their elevation and map coordinates with respect to the Colorado State Planar Coordinate System. All locations will be surveyed to the nearest 0.1 foot vertically and 3 feet horizontally.

3.6.2 Decontamination of Equipment and Materials

All drilling and/or grouting equipment which comes into contact with a well or materials from a well will be decontaminated by steam cleaning at the contractor decontamination pad after each closure. In addition, any scrap metal removed from a well during its closure will be steam cleaned and stored in a location to be designated by PMRMA.

3.6.3 Waste Handling and Minimization

Solid and liquid wastes generated during abandonment activities under Task IRA-3 will be handled in accordance with EPA policy guidelines established in a letter to Colonel W.N. Quintrell dated July 19, 1985 and summarized in Appendix B.

3.6.4 Water Used in Geotechnical Program

Water for use in drilling, grouting, and decontaminating equipment will be of potable quality. Water for these applications will be obtained from the RMA fire department water supply.

3.7 FIELD DOCUMENTATION

Documentation of the techniques utilized in the closure of each well will be provided by completing the applicable portions of the Task IRA-3 database information forms (Appendix A). This information will document the initial status of the well, closure activities completed on the well, and provide a closure construction detail. The Army Quality Assurance Officer will review all field documentation for completeness and perform field audits to assure accuracy of the closure information.

SECTION 4

COMPLIANCE WITH ARARs

4.1 INTRODUCTION

According to the provision of the proposed Consent Decree (Paragraph 9.7), the Interim Response Actions (IRAs) shall, to the maximum extent practicable, attain Applicable or Relevant and Appropriate Requirements (ARARs). In the Final Decision Document for the Interim Response Action for the Closure of Abandoned Wells at Rocky Mountain Arsenal (June 1988), the U.S. Army Program Manager's office for Rocky Mountain Arsenal Contamination Cleanup (PMRMA) presented the analyses of ARARs and documented ARARs that are deemed relevant and appropriate for this IRA.

In the conduct of this task, the Army will comply with those requirements as set forth in the Final Decision Document. The analyses presented in the Final Decision Document deal with ARARs in three specific areas: ambient- or chemical-specific; location-specific; and performance, design, or other action-specific. In the following paragraphs, the discussion that was presented in the Decision Documents related to these specific ARARs is summarized.

4.2 AMBIENT- OR CHEMICAL-SPECIFIC ARARs

Ambient- or chemical-specific ARARs set health or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. Such ARARs set either protective clean-up levels for the chemicals of concern in the designated media or indicate an appropriate level of discharge.

For purposes of the Abandoned Well Closure IRA, there are no pertinent ambient- or chemical-specific ARARs.

4.3 LOCATION-SPECIFIC ARARs

Location requirements set restrictions on remedial activities based on the characterization of the site or the immediate environment.

For purposes of the Abandoned Wells Closure IRA, there are no pertinent location-specific ARARs. However, some of the wells to be closed are located at or near the habitation areas of federally-protected species. According to the requirements of the Consent Decree (Paragraphs 23.2 e and f), the wildlife habitats shall be preserved and protected. Paragraphs 23.2(e) and (f) provide that:

> (e) Wildlife habitat(s) shall be preserved and managed as necessary to protect endangered species of wildlife to the extent required by the Endangered Species Act, 16 U.S.C. Sections 1531 et. seq., migrating birds to the extent required by the Bald Eagle Protection Act, 16 U.S.C. Sections 668 et. seq.
>
> (f) Other than as may be necessary in connection with a Resource Action or as necessary to conduct or operate a Response Action Structure, there shall be no change permitted in the geophysical characteristics of RMA that has a significant effect on the natural drainage at RMA for floodplain management, structures, and protection of wildlife habitat(s).

The Army, based on communication with the U.S. Fish and Wildlife Services, concluded that apparently there would not be any adverse impacts on any endangered species, migratory birds, or the protection of wildlife habitats because the Army has agreed to accommodate all of the concerns of the Fish and Wildlife Services during the implementation of this IRA.

Furthermore, the Army has separately determined that this IRA will not change the physical characteristics of RMA in a manner that will have significant effect on the natural drainage at RMA for floodplain management, recharge of groundwater, and operation and maintenance of Response Action Structure.

The Army will comply with these requirements for the conduct of this task and will perform all closure activities in the area designated for wildlife habitation in association with the U.S. Fish and Wildlife Services.

4.4 PERFORMANCE, DESIGN, OR OTHER ACTION-SPECIFIC ARARs

Performance, design, or other action-specific ARARs set restrictions on particular kinds of activities related to the management of hazardous substances, pollutants, or contaminants. These action-specific requirements may specify particular performance levels, actions, or technologies, as well as specific levels for discharged or residual chemicals.

In the Final Decision Document, the Army has initially identified that two specific activities or actions (well closure and management of excavated materials) pertaining to the implementation of this IRA will require compliance with the following relevant and appropriate ARARs.

WELL CLOSING

(i) 40 CFR Section 144.12(a) -- Provides in pertinent part that a well shall not be abandoned in a manner that allows movement of fluid containing any contaminant into an underground source of drinking water if this causes a violation of a primary drinking water regulation under 40 CFR Part 142 or otherwise may adversely affect the health of personnel.

(ii) 40 CFR Section 144.28(c)(2) -- Provides for submission of a plugging and closure plan that includes the following information:

(a) The nature, quantity, and material to be used in plugging;

(b) The location and extent (by depth) of the plugs;

(c) Any proposed test or measurement to be made;

(d) The amount, size, and location (by depth) of casing to be left in the well;

(e) The method and location where casing is to be parted; and

(f) The estimated cost of plugging the well.

The well is to be plugged and closed in accordance with the plan except with notice to and approval by the EPA Regional Administrator.

(iii) 40 CFR Section 146.10(a)-(c)

(a) Prior to closing Class I to III wells the well shall be plugged in a manner which will not allow the movement of fluids either into or between underground sources of drinking water. The Director may allow Class III wells to use other plugging materials if he is satisfied that such materials will prevent movement of fluids into or between underground sources of drinking water;

(b) Placement of the cement plugs shall be accomplished by one of the following:

(1) The Balance method;
(2) The Dump Bailer method;
(3) The Two-Plug method; or
(4) An alternative method approved by the Director, which will reliably provide a comparable level of protection to underground sources of drinking water.

(c) The well to be closed shall be in a state of static equilibrium with the mud weight equalized top to bottom, either by circulating the mud in the well at least once or by a comparable method prescribed by the Director, prior to the placement of the cement plug(s).

The regulations described above (UIC Program) are intended to protect underground sources of drinking water. The Army, however, identified these regulations are not applicable to this IRA since this IRA is being conducted pursuant to Sections 120 and 121 on a CERCLA Site where the drinking of groundwater is prohibited.

The Army specified in the Final Decision Document (June, 1988) that closure methods will follow standardized procedures in use by water well contractors and in accordance with USATHAMA Quality Assurance/Quality Control procedures which are in compliance with EPA and State of Colorado standards for well sealing (Colorado State Board of Examiners of Water Well and Pump Installation Contractors, 1984). The procedures for well closure are described in Section 3.0 of this plan. In performance of this work, WESTON will follow the procedures set forth in Section 3.0.

EXCAVATED MATERIAL

Excavated material will be screened in accordance with the memorandum of June 12, 1985, from EPA Region VIII (Appendix B). Material determined to be potentially contaminated will be managed under the provisions of that memorandum. If material is determined to be hazardous waste, it be will further managed pursuant to substantive RCRA requirements, as found in 40 CFR Parts 261-264.

SECTION 5

CHEMICAL ANALYSIS PLAN

5.1 INTRODUCTION

Prior to closure, samples from selected wells will be analyzed for volatile halogenated organic compounds, organochlorine pesticides, phosphonates (diisopropyl and dimethyl methylphosphonates), metals (arsenic and mercury), and dibromochloropropane. The results of these analyses will provide an indication of the current state of contamination in the wells samples.

5.2 ANALYTICAL METHODS

The analytical methods used in support of Task IRA-3 will be based on published Environmental Protection Agency methods when appropriate methods exist. Dibromochloropropane and the methylphosphonates do not have published EPA methods appropriate for their analyses. These compounds will be analyzed using methods developed during the course of studies at RMA. Each of the methods used for this task will be USATHAMA certified according to the guidelines for Class 1 certification.

5.2.1 Volatile Halogenated Organics

Volatile halogenated organics will be analyzed using a modified version of EPA Method 601. The samples will be purged to strip the volatile compounds from the aqueous solution and these volatile compounds will be trapped on a solid sorbent. The compounds will then be heat desorbed and backflushed directly onto the gas chromatographic column for separation and detection using a Hall electroconductivity detector (HECD).

5.2.2 Organochlorine Pesticides

Organochlorine pesticides will be analyzed using a modified version of EPA Method 608. The samples will be extracted three times with methylene chloride. The extracts will be combined and concentrated on a Kuderna-Danish apparatus. During the concentration process, the solvent will be exchanged to hexane. Analyses will be conducted by gas chromatography using an electron capture detector.

5.2.3 Phosphonates

The diisopropyl and dimethyl methylphosphonates will be analyzed by extracting the samples three times with methylene chloride. The extracts will be combined and concentrated on a Kuderna-Danish apparatus. The solvent will be exchanged to isooctane, and analyses will be conducted by gas chromatography with a nitrogen/phosphorus detector.

5.2.4 Metals

Mercury will be analyzed by cold vapor atomic absorption spectroscopy according to EPA Method 245.1. The sample will be digested with potassium permanganate in an autoclave. Ionic mercury will be then reduced by stannous sulfate, and elemental mercury will be vaporized and detected.

Arsenic will be analyzed according to EPA Method 206.2. The sample will be digested with hydrogen peroxide and nitric acid. Arsenic will be then determined by graphite furnace atomic absorption spectroscopy.

5.2.5 Dibromochloropropane

Analysis for dibromochloropropane will require extraction of the sample with hexane. The extract will be analyzed by gas chromatography with an electron capture detector.

SECTION 6

QUALITY ASSURANCE PROGRAM

6.1 PROJECT QUALITY ASSURANCE/QUALITY CONTROL PLAN

An integral part of the Technical Plan is the Quality Assurance/Quality Control (QA/QC) Plan which describes the procedures for documentation, monitoring, and quality verification of the field and analytical work to be conducted at RMA. The objectives of the QA/QC Plan are the following:

- Document, monitor and verify that the established PMO/USATHAMA Quality Assurance Program guidelines and standards are met.
- Document, monitor and verify the precision and accuracy of data collected and analyzed.
- Document, monitor and verify the validity of procedures and systems used to achieve the project goals.
- Determine quickly any deficiencies affecting the quality of the data.
- Perform corrective actions which are approved and documented according to the Technical Plan.
- Monitor and verify that the data acquired will be documented sufficiently to be legally defensible.
- Document, monitor and verify that the precision and accuracy levels attained during the USATHAMA analytical certification program are maintained during the project.

Dr. Edward Gilardi, P.E., the Corporate Quality Assurance Officer, has overall project QA/QC responsibility for the RMA Abandoned Well Closure Program. The Quality Assurance Team consists of the Corporate Quality Assurance Officer, the Analytical Quality Assurance Coordinators and the Geosciences Work Element Group Leader. Each of these positions and the responsibilities associated with them will be discussed in the

Management/Resource Plan for the RMA Abandoned Well Closure Program to be submitted by December 21, 1988.

The project organization and responsibilities of the principal personnel will also described in detail in the Management/Resource Plan for the RMA Abandoned Well Closure Program to be submitted December 21, 1988. Therefore, the principal technical, management and quality assurance/quality control personnel will not be defined in this section.

6.2 SPECIFIC PROJECT REQUIREMENTS

The USATHAMA geotechnical requirements for well acceptance, sampling, topographic surveying, well abandonment and selected data management entries and geotechnical reports are set forth in Appendix B of Sampling and Chemical Analysis Quality Assurance Program for U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). Appendix B is used as a source, where appropriate, for the following geotechnical requirements.

6.2.1 Geotechnical Requirements

Topographic Survey

Prior to abandonment, each well will be topographically surveyed by a licensed surveyor to determine its map coordinates with respect to the Colorado State Planar Coordinate System to within ± 3 feet (± 1 meter). The ground surface elevation will be surveyed to within ± 0.1 foot (± 3 centimeters) using the National Geodetic Vertical Datum of 1929. Survey field data (as corrected), to include loop closure for survey accuracy, will be submitted to USATHAMA to the Contracting Officer within the draft geotechnical or draft final report submission, whichever occurs first. The submission will list the coordinates (and system) and ground surface elevation for each well and reference mark. All permanent and semi-permanent reference marks used for horizontal and vertical control will be described in terms of their name, character and physical location.

Well Abandonment

A geologist will be present during the well abandonment procedure to document and verify that the operations are completed according to the Technical Plan and USATHAMA requirements. Field procedures and occurrences will be documented in the geologist's bound logbook. All entries will be made with a waterproof pen. Documentation in the geologist's logbook will include, but may not be limited to the following:

- Name and location of well.
- To the extent known or measureable, boring depth and diameter; surface and well casing interval, diameter and materials; screen interval, diameter and materials; and seal interval and materials.
- Description of closed well in terms of boring depth and diameter; surface and well casing interval, diameter and materials; screen interval, diameter and materials; and seal interval and materials.
- Description of the closure methods followed.
- Any significant observations made during the closure procedure.
- Geologic and mechanical problems encountered during well abandonment.
- Start up and quitting times.
- Record of supplies used during abandonment procedure.
- Date and initials or signature of geologist.

Copies of field logbooks and well closure documents will be delivered to data management on a weekly basis. The field data will be reviewed for data consistency and logic prior to entry into the data management system.

Field audits will be conducted on a periodic basis by the field QA/QC representative to document and verify that the field work and data acquisition is following the prescribed technical guidelines. If any discrepancies or deficiencies in the data acquisition, field work, or field method are determined, appropriate corrective actions will be implemented.

The QA/QC representative will not document and verify his acceptance of the data or field method until the corrective action is completed.

6.2.2 Field Sampling

Prior to closure, samples from selected wells will be analyzed for volatile halogenated organic compounds, organochlorine pesticides, phosphonates (diisopropyl and dimethyl methylphosphonates), metals (arsenic and mercury), and dibromochloropropane. The results of these analyses will provide an indication of the current state of contamination in the wells.

The management of samples, from the time of collection through the shipment and arrival of the samples at the laboratory, will be under the supervision of the Geosciences Work Element Group Leader. The following describes the well sampling protocol and the chain-of-custody protocol which will be followed during the RMA Abandoned Well Closure Program. The ground-water samples will be collected with properly decontaminated equipment after appropriate well purging, in properly cleaned and labeled containers, and preserved and transported according to prescribed methods. If deviations from the sampling protocol result in a compromise of sample integrity, the affected samples will be discarded, and the wells will be resampled according to the prescribed protocol.

Sample Containers

The following table lists the sample containers which will be used for ground-water sampling. Teflon liners will be used in all but the volatile organic analysis bottles. All sample bottles will be precleaned according to standard laboratory procedures at the laboratory or manufacturers prior to shipment.

Analysis	Container
Volatile Organic Compounds (VOA)	40 ml amber glass bottle with teflon septum cap.
Organochlorine Pesticides	1 liter amber glass bottle
Phosphonates (diisopropyl and dimethyl methylphosphonates)	1 liter amber glass bottle
Metals (arsenic and mercury)	1 liter plastic bottle
Dibromochloropropane	1 liter amber glass bottle

Decontamination of Sampling Equipment

Pumps and ground-water sampling equipment will be cleaned as follows to prevent cross contamination between wells:

1. Fresh water rinse (2 volumes)
2. Alconox detergent wash (2 volumes)
3. Fresh water rinse (3 volumes)
4. Distilled water rinse (2 volumes)
5. Reagent methanol rinse (1 volume)
6. Reagent distilled water rinse (3 volumes)

Monitor Well Sampling

Prior to sampling a well, the water level from the top of casing will be measured, the volume of water in the well will be calculated, and the well will be purged of five times the calculated well volume with a pump or bailer. USATHAMA geotechnical guidelines require that wells will be purged of five times the calculated well volumes prior to sampling. If the well is pumped/bailed dry prior to purging the prescribed well volumes, the well will be allowed to recover, and then will be pumped/bailed dry a second time. The well will be sampled immediately after purging. In cases where the well is pumped dry and recovery is slow, the samples will be taken as soon as possible after the well has recovered.

The sampling equipment will be protected from ground contamination by clean plastic sheeting. Care will be taken to prevent windblown particles from contaminating the sample or sampling equipment.

Prior to collecting the ground-water sample, the sample bottle will be rinsed with the water to be sampled. The bottle will then be filled to the top and the bottle capped securely.

In order to maintain the integrity of the ground-water sample from the time of collection until the analyses are performed, the samples will be preserved according the USATHAMA and USEPA procedures and techniques. The preservation of samples will be performed in the field prior to shipment or storage of the samples. All samples will be stored in ice chests at a temperature at or below four degrees Celsius. Table 6-1 describes the sample preservation methods, the analytical methods to be used and the holding times for each analyte.

TABLE 6-1

ANALYTICAL METHODS

Analyte	Preservation Method	Analytical Method	Holding Times
MATRIX: Groundwater			
Volatile Halogenated Organic Compounds	Ship and store at 4°C	Purge-trap; GC-Hall (Modified EPA 601)	14 days
Organochlorine Pesticides	Ship and store at 4°C	CH_2Cl_2 Extract; Exchange to Isooctane; GC-EC (Modified EPA 608)	7 days/ 21 days
Phosphonates	Ship and store at 4°C, Preserve with $CHCl_3$	CH_2Cl_2 Extract; GC-NPD (USATHAMA 45)	7 days
Arsenic	May be shipped and stored at room temperature, HNO_3 to pH<2	Cold Vapor - AA(EPA 206.2)	6 months
Mercury	May be shipped and stored at room temperature, HNO_3 to pH<2	Cold Vapor - AA(EPA 245.1)	28 days
Dibromochloropropane (DBCP)	Ship and store at 4°C	Hexane extract; GC - Electron Capture Detector	7 days 40 days

Sample Labeling and Identification

The sample label will be completed in the field with a waterproof pen. The label will identify the well number, the site identification code, the sample number, the date and time of sampling, the sample technician's name and signature, the type of analyses to be performed, and preservation notes. A label will be affixed to each sample bottle at or before the time of sampling.

Recordkeeping

The field personnel will maintain a bound logbook of field activities and ground-water sampling data. The following information regarding sampling will be included in the field logbook:

- Time and date of sample collection.
- Matrix being sampled (ground water).
- Well identification and location.
- Sample identification number.
- Method of well purging and sampling.
- Significant observations made during the sampling process
- Samples collected, preservation methods.
- Signature of person performing the sampling.

Field Sample Management

The sampling personnel will label, preserve, store, and transport the samples according to the prescribed methods. Periodic audits will be conducted by the field QA/QC representative to document and verify that the prescribed methods are being implemented.

Chain-of-Custody Procedures

To verify the integrity of the samples collected and analyzed, the locations and individuals responsible for the samples must be traceable from the time of sample collection until the samples are analyzed. The field sampler will complete sample labels, chain-of-custody seals, and chain-of-custody forms for the samples collected. The chain-of-custody forms also include information regarding the analyses requested for each sample. Figures 6-1 and 6-2 present copies of a chain-of-custody form and a custody seal. All sample shipments will contain a chain-of-custody form. The original forms will accompany the samples to the laboratory, and a copy will remain with the field sampler. The field sampler will deliver the copy of the chain-of-custody to the data management group for entry into the data management system.

6.2.3 Laboratory Quality Assurance Procedures

All reference materials to be used in PMRMA programs will be traceable to USATHAMA, Environmental Protection Agency, or the National Bureau of Standards. When available, Standard Analytical Reference Materials (SARM's) will be obtained from USATHAMA; in the absence of available SARM's, interim reference materials will be used and characterized as outlined in Section 6.5.3 of the USATHAMA QA Program. For costing purposes, reference materials are assumed to be available from USATHAMA. Documentation of the characterization will be submitted with the precertification data package.

Documentation of analyses performed for PMRMA programs will be maintained in bound notebooks. Laboratory management and the laboratory QAC will be responsible for auditing these notebooks for completeness and accuracy.

Custody Transfer Record/Lab Work Request

WESTON

WESTON Analytics Use Only

Client _____

Work Order _____

Date Rec'd. _____ Date Due _____

RFW Contact _____

Client Contact/Phone _____

WA Use Only Lab ID	Client ID/Description	Matrix	Date Collected	Refrigerator#	#/Type Container	Containers/Volume	Preservative	ANALYSES REQUESTED

Matrix:
S - Soil
SE - Sediment
SO - Solid
W - Water
O - Oil
A - Air
DS - Drum Solids
DL - Drum Liquids
F - Fish
X - Other

Special Instructions:

Item/Reason	Relinquished by	Received by	Date	Time	Item/Reason	Relinquished by	Received by	Date	Time

WESTON Analytics Use Only

Samples Were:
1 Shipped or Hand-Delivered
NOTES:

2 Ambient or Chilled
NOTES:

3 Received Broken/Leaking (Improperly Sealed)
Y N
NOTES:

4 Properly Preserved
Y N
NOTES:

5 Received Within Holding Times
Y N
NOTES:

COC Tape Was:
1 Present on Outer Package Y N
2 Unbroken on Outer Package Y N
3 Present on Sample Y N
4 Unbroken on Sample Y N
NOTES:

COC Record Was:
1 Present Upon Receipt of Samples Y N

Discrepancies Between Sample Labels and COC Record? Y N
NOTES:

7-115

RFW 21-21-001/A-5/88

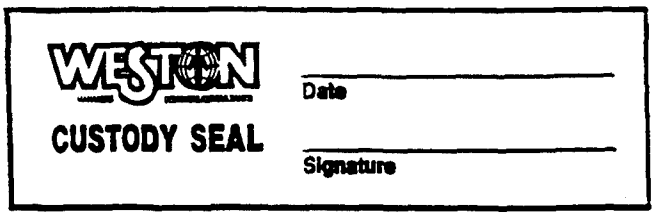


Figure 6-2: CHAIN OF CUSTODY SEAL

Prior to conducting analyses on an independent basis, analysts are trained by experienced personnel in the complete performance of an analytical method. If instrumentation is particularly complicated, analysts are trained at manufacturers training courses. QC sample results (blanks and method spikes) from newly trained analysts are monitored closely by the appropriate laboratory manager for accuracy and consistency.

In addition to daily calibration, QC spikes and blanks in standard matrices will be required with each analytical lot. At least one method blank is required for each analyte in each lot. For Class 1, three QC spikes for each analyte in each lot will be analyzed: one at 2X and two at 8X where X is the certified reporting limit. These data will be used for maintenance of the QC charts.

6.2.4 Laboratory Analytical Controls

During periods of actual analyses under this contract, the WESTON laboratory team will establish and maintain control charts as required by the USATHAMA QA Program. Currently, required control charts include four different types: X (percent recovery); R (range of recoveries); 3-point moving average for X; and 3-point moving average for R. The data obtained during the certification process will be used to calculate the central lines as well as the upper and lower warning and control limits for initialization of the control charts. These limits will be calculated using the USATHAMA PC-based control chart program. Daily results from QC samples will be used to update the control limits for the first twenty analytical lots.

After 20 lots, all points (including outliers) will be used to establish new control limits. Historical points falling outside of the new control limits will be dropped, and new limits will be calculated to control subsequent analyses.

The control charts will be used to monitor the analytical systems for out-of-control situations. Out-of-control situations may be indicated by a value outside the control

limits, seven successive points on the same side of the central line, five successive points going in the same direction, two consecutive points between the warning and control limits, or a cyclical plot. When a system is determined to be out of control, corrective actions will be initiated, and the occurrence will be fully documented. Any data obtained since the last determination of being in control will be considered invalid. The system will be brought back in control prior to continuing analyses.

Prior to reporting generated data, the data will be reviewed by laboratory management. The laboratory QAC will monitor the analytical systems on each day of analyses and will submit the graphical precision and accuracy control charts on a weekly basis. The submissions will also include tabulated control chart data and narratives on data evaluation and any actions taken to correct out-of-control situations. These reports will be submitted so that receipt by the COR will be not later than four working days after completion of the week's analyses.

6.2.5 Laboratory Data Management, Review Validation, and Reporting Procedures

Routinely, schedules of samples expected to arrive at the laboratory are provided to laboratory management prior to actual delivery. This advance notice allows the laboratory management to tentatively schedule analyses for those samples. On the day of actual arrival, copies of the chains-of-custody are provided to each of the laboratory managers, senior analysts, and the Analytical Work Element Manager to alert them that the samples have arrived.

Chain-of-custody documents for each sample will be initiated in the field and will accompany the samples to the laboratory. Site identification (ID) codes will be used to correlate the field locations and chemical analysis data. At the time of log-in, chain-of-custody documents will be signed to acknowledge receipt, and samples along with the

appropriate parameters to be analyzed will be entered into a bound sample log-in notebook.

The laboratory quality assurance coordinator (QAC) will assign analytical lot numbers to the samples. The first three letters of the six-character sample code will designate the analytical lot, while the remaining three digits will indicate the sample number within the lot (e.g., AAB006 indicated the sixth sample in lot AAB). QC samples within the lot will also receive USATHAMA sample numbers. Different lot numbers will be used for each analytical method and for each lot analyzed by a particular method.

When analyses are complete, the analyst will reduce the data for the QC samples first to determine if the analyses were in control based on control limits established from previous analyses. The QC results will then be forwarded to the laboratory data management group for inclusion in and construction of control charts. New control limits will be determined for guidelines for subsequent analyses. If the most recent QC results represent the end of the week's analyses, control charts will be generated and reviewed for submission.

The Data Manager will be responsible for the tracking of each sample received by the laboratory from the time of receipt to transmission of data to the USATHAMA database network at Edgewood. When data reduction has been completed for the samples, the analyst will complete the data management coding forms and return them to the Data Manager for entry into Level 1 in the local PC IRDMS. Each analytical lot will be subjected to the record check routine to determine entry errors associated with incorrect analytes, certification, holding times, etc. Entry errors will be corrected using the edit function of the program. When the analytical lot is found to be clean by the record check routine, the lot will be subjected to the group check routine to detect errors in the site ID's, numbers of QC samples, QC spiking levels, etc. Any errors (technical as well as format) in Level 1 will be corrected prior to attempt to transmit the data to the

USATHAMA Database network. When the data have successfully passed the group check routine, the data will be converted to a transfer file for transmission to the network at Edgewood.

Data transmissions to the USATHAMA Database network at Edgewood will be made as data pass the record and group check routines. This is anticipated to occur several times per week during periods of actual analyses. The local PC will be linked to the network using USATHAMA database software (3Com) and a Hayes modem. Alternatively, transmission of data may be performed by a PC-PC connection when difficulties with the network are encountered. Terminal usage logs will be established and maintained as a permanent record of communications with the network. Data will be sent to the network within 10 working weeks after sample collection, and the COR will be notified within 5 days of data transmission.

Should any problems develop that result in the inability to transmit data, the COR will be notified of the difficulties, and other means will be sought (i.e., hard copy or floppy disk) for forwarding data. Once data have been transmitted to the 3Com network, have been processed through the verification error routine, and passed on to Level 2, files in Levels 2 and 3 will be the responsibility of the Government.

SECTION 7

DATA MANAGEMENT PROGRAM

7.1 INTRODUCTION

The Data Management Plan is designed to provide structured guidelines for the collection, storage, and validation of all data associated with the performance of Task IRA-3 of the Interim Response Action for the Closure of Abandoned Wells at Rocky Mountain Arsenal.

The nature of this task requires that the Army compile a database of historical groundwater well information from the Rocky Mountain Arsenal, and add to this database new data acquired during the course of actual field investigations. All data obtained during the course of this program will be used to document actual well construction and closure details.

Evaluating groundwater wells at Rocky Mountain Arsenal for closure recommendations requires that appropriate closure criteria be established and applied with some level of consistency. For this reason all accumulated data will be entered into a new, comprehensive PC-based database (Task IRA-3 database) at WESTON's Lakewood, Colorado office. This Task IRA-3 database will be used to combine and document RMA well data from:

a) Existing databases (i.e., Task 37 database, RMA Information Center database, etc.)

b) Hard copy historical records (i.e. borehole logs, well logs, etc.)

c) Task IRA-3 field data collected during well search and well closure activities.

The Task IRA-3 database will permit efficient manipulation and comprehensive evaluation of the stored data, which can provide a basis for developing well closure recommendations and for planning Task IRA-3 field activities.

7.2 DATABASE ORGANIZATION

Two distinct databases will be used by the Army to organize data collected or generated concerning the RMA groundwater wells during Task IRA-3. The first of these is the Task IRA-3 database currently under development at the WESTON Lakewood office. This database will include all available information concerning the location, construction, and use/status of each well included in Task IRA-3 including both recent (post-1942) monitoring wells and pre-Arsenal (pre-1942) farm wells. The second database is the USATHAMA IRDMS; a version of which will be installed at the Lakewood office. The USATHAMA IRDMS database will be used to document all sampling and analytical results obtained from any groundwater sampling of the Arsenal wells performed during this task.

7.2.1 Groundwater Well Historical Database

The initial version of the Task IRA-3 database will include data about the location, construction and purpose of each identified groundwater well at the Arsenal, as well as data for many borcholes. This information is being accumulated from a variety of sources, including the Rocky Mountain Arsenal Information Center, previous work by ESE and Ebasco, and data on pre-Arsenal (pre-1942) farm wells compiled by Geraghty and Miller under Task 37 of the Interim Response Action. In addition to the above sources, the pre-1942 farm well data were obtained from the Corp of Engineers (COE), United States Geological Survey (USGS), farm real estate appraisals performed when the Arsenal was created, and previous field surveys performed by Geraghty and Miller in Task 37. In the course of investigating and evaluating wells for closure, The Army will generate

considerable additional data for many of these wells. Addition, deletions, or modifications to the Task IRA-3 database will be made as required.

The Task IRA-3 database will include all available well construction information such as casing diameter and length, construction materials, screen intervals and their locations in each well, seal and grout depths, and the method of well construction or closure used for each of the wells addressed in this task. This database will also contain well identification information such as well number and associated bore number, location information including State coordinates, and a variety of logical fields to indicate the present status of closure plans for each well. Finally, the Task IRA-3 database will provide a record of all field activities concerning each well, including records of both past and present searches and investigations associated with each well. More specific details of the information/topic headings to be addressed in the new database are described in Appendix A.

7.2.2 Installation Restoration Data Management System

In addition to the well construction/status/closure data developed during Task IRA-3, any of the wells subjected to groundwater sampling during the task will have corresponding sampling and analytical data. These data will be entered into the USATHAMA IRDMS, which is to be installed at both the WESTON Lakewood office, and at each of the labs conducting analyses of the samples. The Lakewood office will submit sampling data, while the labs will be responsible for the entry, verification and submission of chemical analysis data.

7.3 HISTORICAL DATA

The data currently available for each well at Rocky Mountain Arsenal, as well as new data acquired during the performance of Task IRA-3, will be compiled into the Task IRA-3 database described in Section 2.1. This database is being developed by the Army

as a tool to ensure that standardized criteria are used in the evaluation of wells for closure, and to efficiently plan the Task IRA-3 field activities.

Pre-1942 Rocky Mountain Arsenal Farm Wells

Data entered into the Task IRA-3 database will come from a variety of different sources and must therefore be verified using methods appropriate to the source of the data. Most of the data available on the pre-1942 wells has been compiled by Ebasco Services, et al., (1988), and includes data from previous work by Morrison-Knudsen (1985), the U.S. Army Corp of Engineers (1962), the U.S. Geological Survey, and various farm appraisals, aerial photographs and maps. The old farm well data will be verified against the original reports (where possible) prior to entering it into the Task IRA-3 database. The Task IRA-3 database will be updated as field crews collect additional new data or confirm, through measurement, previously reported data concerning the wells.

Where the source of the original data cannot be determined, or the reported data cannot be confirmed through field research, the data of record will be considered unacceptable and flagged as such in the database. Data considered unacceptable will not be removed from the database because, although unsubstantiated, data of this category may be a factor in the decision to recommend a well for closure.

Post-Rocky Mountain Arsenal Monitoring Wells

Much of the data available for post-1942 monitoring wells has been compiled into a database by Dp Associates at the Rocky Mountain Arsenal Information Center. This database has been incorporated into the RMA database, and contains some basic well construction information. WESTON is verifying the information found in the Information Center database against original borehole/well records, and adding to the Task IRA-3 database any additional well construction information found. Data from the borings are being transferred to individual hard copy files for each of the wells using a standardized Well Construction Survey form, Figure 3-1, which will be used to update the

Task IRA-3 database. The data recorded on this form are verified against the original bore logs prior to keyboard input into the database. Computer reports of the data input are then generated and verified against the Well Construction Survey forms.

All keyboard input will be subject to a multi-level Input/Verify/Edit/Verify Q/A system. All verifications will be performed by personnel familiar with the technical significance of the data being verified. In no case will the data entry and the data verification be performed by the same person.

7.4 FIELD DATA

The Field Team Leader is responsible for managing all field data collection activities and sample logging procedures. Field notebooks and the Well Construction Survey form will be used to document field activities and will be verified for accuracy and completeness by qualified geotechnical personnel It will be the Field Team Leader's responsibility to see that all field data are documented and meet the Q/A procedures outlined in Section 6 of this plan. The field data collected on the Well Construction Survey forms will be transferred to the Data Manager for review and input into WESTON's Task IRA-3 database and/or the USATHAMA IRDMS database (for sampling/analytical data).

Field Data Verification

All field data entry will be subject to a multi-level Input\ Verify\Edit\Verify Q\A protocol. The field data input sheets, after having been verified for accuracy and completeness by the geotechnical staff, will be assigned to an Input Clerk by the Data Management Work Element Leader (Data Manager). After input has been completed the Input Clerk will return the data package to the Data Manager who will then assign the data package to a First Verifier. The First Verifier will be someone with a technical understanding of the data and must be someone other than the Input Clerk. The First

Verifier will check the input against a computer printout of the newly entered data, and look for errors of either a technical or clerical nature. The data package will then be returned to the Data Manager who will assign it to a First Editor for corrections. The First Editor may be the original Input Clerk or the First Verifier as long as the data was physically returned to the Data Manager between each verification step and reviewed prior to re-assignment. The First Editor will make any necessary corrections to the database, and return the data package to the Data Manager. The data will then be assigned to a Second Verifier, also someone with technical competence and familiarity with the meaning of the data, who will review the edits and then return the data package to the Data Manager.

The data verification process will continue with a Second Editor/ Third Verifier, etc. until no input errors are detected in the database.

The Data Manager will maintain a logbook of the data review process in which the data package will be logged upon receipt, and in which the Data Manager tracks the status of the data review process. All persons assigned to any level of the review process will sign out the data package upon receipt from the Data Manager, and sign off on it upon returning it to the Data Manager..

7.5 ANALYTICAL DATA

Schedules of samples expected to arrive at the laboratory are provided to laboratory management prior to actual delivery. This advance notice allows laboratory management to tentatively schedule analyses for those samples.

Chain-of-custody (COC) documents for each sample will be initiated in the field and will accompany the samples to the laboratory. On the day of sample arrival, copies of the chain-of-custody documents are provided to each of the Laboratory Managers, senior analysts, and the Analytical Task Manager and the Data Management Work

Element Leader to alert them that the samples have arrived. Site identification (ID) codes will be used to correlate the field locations and chemical analysis data. At the time of log-in, chain-of-custody documents will be signed to acknowledge receipt, and samples, along with the appropriate parameters to be analyzed, will be entered into a bound RMA-specific sample log-in notebook. The sample data will be entered into the USATHAMA IRDMS on the local PC system to generate data coding forms for each sample. The sample forms will be provided to the analysts for completion as the analytical results become available.

The Laboratory QAC will assign analytical lot numbers to the samples. The first three letters of the six-character sample code will designate the analytical lot, while the remaining three digits will indicate the sample number within the lot (e.g., AAB006 indicates the sixth sample in lot AAB). QC samples within the lot will also receive USATHAMA sample numbers. Different lot numbers will be used for each analytical method and for each lot analyzed by a particular method. Samples within a lot will be numbered sequentially.

When the analyses are complete, the analyst will reduce the data for the QC samples first to determine if the analyses were in control based on control limits established from previous analyses. The QC results will then be forwarded to the laboratory data management group for inclusion in and construction of control charts. New control limits will be determined for guidelines for subsequent analyses. If the most-recent QC results represent the end of the week's analyses, control charts will be generated and reviewed for submission in accordance with data requirement A008. When data reduction has been completed for the samples, the analyst will complete the data management coding forms and return them to the Data Management Work Element Leader for entry into Level 1 in the local PC IRDMS. The Data Management Work Element Leader will be responsible for the tracking of each sample received by the laboratory

from the time of receipt through transmission of data to the central USATHAMA database. The biweekly sample status log will be submitted by the Data Management Work Element Leader to the Task Manager who, in turn, will submit it to the PMRMA.

7.6 SAMPLE TRACKING

The Data Manager will be responsible for monitoring the location and status of all analytical samples from collection in the field through the reporting of the analytical results to the IRDMS network. Each day that samples are sent from the field to the laboratory a copy of the COC will be provided to the Data Manager by the field personnel. This copy of the COC will be considered by the Data Manager to be notice of sampling activity. The Data Manager will use the information from each COC to establish and maintain a log file for the samples with which the samples can be tracked. Upon receipt and log-in of the samples by the analytical laboratory a copy of the COC will be returned to the Data Manager to provide evidence that the samples arrived at the lab safely and in a timely manner.

The Data Manager, in conjunction with the Analytical Task Manager, will review sample status at least once per week and use this review as the basis for a biweekly status report to the Task Manager. The Task Manager will in turn submit this report to the Program Manager Rocky Mountain Arsenal (PMRMA).

SECTION 8

HEALTH AND SAFETY PROGRAM

8.1 INTRODUCTION

This Health and Safety Plan provides guidance and establishes procedures for well abandonment activities at the Rocky Mountain Arsenal, Denver, Colorado. The intention of the plan is to establish safety policy and general standards, and to provide the framework for more specific safety requirements to be employed. This plan applies to all prime and subcontractor personnel working on this assignment and to visitors at project work locations. All affected personnel will be required to sign a statement to the effect that this document has been reviewed and understood prior to commencement of on-site activities and/or visits to the work location. THERE ARE NO EXCEPTIONS. The Plan will be revised, if needed, based on additional site information and changes in field conditions and activities.

8.1.1 Standards

The Rocky Mountain Arsenal Health and Safety Plan is based on the following State regulations, Federal regulations, and WESTON corporate policy:

- State of Colorado Hazardous Waste Regulations.
- 29 CFR Part 1910, "Occupational Safety and Health Standards."
- 29 CFR Part 1910.120, "Hazardous Waste Operations and Emergency Response, Interim Final Rate."
- 29 CFR Part 1926, "Construction Standards."

- o 49 CFR Parts 172-174, "DOT Transportation of Hazardous Materials."
- o Roy F. Weston, Inc., Corporate Health and Safety Protocols.

8.1.2 General Guidelines

Project members will conduct themselves in a professional manner at all times. The following restrictions will be observed:

- o Horseplay or fighting is prohibited.
- o Working while under the influence of intoxicants, narcotics, or controlled substances is prohibited.
- o Firearms, ammunition, and fireworks or explosives are prohibited.
- o Smoking is prohibited, except in designated areas.
- o Loose clothing will not be worn on site. Long hair will be worn "up" inside hard hat.

All personnel working in the field will follow these rules and procedures:

- o Designated safety equipment will be worn at all times. No person will be permitted near work activities without the proper safety equipment, as outlined in this safety plan.
- o No eating, drinking, chewing gum, or chewing tobacco will be permitted in the immediate vicinity of the work sites. Gloves will be removed and hands and forearms will be washed before eating or drinking. If lunch is to be eaten at the site, it will be eaten only within the support zone.
- o A "safe" area will be designated where drinking water and washing facilities will be available.
- o Proper decontamination procedures will be followed before leaving the site area.
- o A minimum of two people will be on site during all operations. If Level C is in use, one additional person will be located within the line of sight in a "safe" area.

- o Additional safety equipment will be donned when action levels are attained, or at the first sign or suspected sign of free hazardous material (odor or taste detected, symptoms of exposure). At such times, the activities will be halted until all crew members are notified and proper safety precautions are followed.

- o A type A B C dry chemical fire extinguisher will be available in all vehicles at all times (minimum 1 pound).

8.1.3 Safety References

The following references were used to prepare this Safety Plan:

- o Dangerous Properties of Industrial Materials.

- o NIOSH/OSHA Pocket Guide to Chemical Hazards.

- o WESTON Operating Procedures (OP) 11-1, 11-2, and 11-4.

- o WESTON's Corporate Health and Safety Plan dated September 1984.

- o NIOSH/OSHA/USEPA/USCG Guidance Manual for Activities at Hazardous Waste Sites (October 1985).

8.2 SITE HISTORY AND DESCRIPTION

8.2.1 Description of Abandoned Well Problem

The Rocky Mountain Arsenal (RMA), located in western Adams County northeast of Denver, Colorado, was established in 1942 as a manufacturing facility for the production of chemical munitions. In 1946, excess facilities at the South Plants area were leased by the Julius Hyman Company for pesticide production. The chemical division of the Colorado Fuel and Iron Company leased several facilities in the same area in the early 1950s. Also during the early 1950s, the Shell Chemical Company purchased the Julius Hyman Company and subsequently leased facilities in the South Plants are for pesticide production.

Before RMA was established, the area was devoted to agricultural and residential use. As many as 250 water wells for irrigation, stock watering, and domestic use were constructed on what is now RMA property. Information on the pre-1942 wells, available from

scattered sources, indicates that about one-half of the wells are greater than 30 inches in diameter and were probably hand-dug. The reported well depths range from 15 to 1,000 feet with approximately 40 wells over 100 feet deep. It is also reported that approximately 40 of the pre-1942 wells have been "filled", and an additional unspecified number have been covered. The remainder of the wells were probably left open (Morrison-Knudsen, 1985, RIC 85343RO1).

In addition, since the establishment of RMA in 1942, hundreds of monitoring wells have been installed on the property. The majority of these wells are in good conditions and still in use. It has been established, however, that approximately 200 of the post-1942 monitoring wells are no longer usable (ESE, 1986, RIC 87013RO1). Information on most of the post-1942 monitoring wells is available from the USATHAMA computer database. These wells are reportedly two to six inches in diameter and 15 to 140 feet deep.

Wells will be both searched for and closed on a priority basis determined by their potential to adversely impact deep aquifers.

8.2.2 Site Description

The RMA encompasses approximately 27 square miles. It is relatively flat prairie grassland. Various production facilities are located in areas of the RMA.

Disposal practices within the RMA have included the discharge of industrial waste effluents to unlined evaporation basins and burial of solid wastes at various locations. In addition, unintentional spills of raw materials, process intermediates, and end products have occurred within the manufacturing complexes at RMA. Many of the compounds are mobile in surface and groundwaters. Disposal activities have been concentrated in Sections 26, 35, and 36.

8.3 RESPONSIBLE INDIVIDUALS

The following project personnel and their safety responsibilities are identified as follows:

- WESTON's Director of Corporate Health and Safety is Mr. George Crawford, telephone 215-430-7406. Mr. Crawford has responsibility for overall contract safety policy, planning, execution, and auditing. He has authority to halt project activities for safety reasons.

- WESTON's Program Manager is Mr. William Lynott, telephone 303-980-6800. Mr. Lynott has responsibility for ensuring that this Safety Plan is implemented. He has authority to halt project activities for safety reasons.

- The Department of the Army Contracting Officer representative, Mr. David Parks, has responsibility for government acceptance of the overall execution of project safety activities. He has authority to require upgrading of safety protocols and to halt project activities for safety reasons.

- WESTON's Task Manager is Mr. Mark Hutson, telephone 303-980-6800. Mr. Hutson has responsibility for ensuring that this Safety Plan is followed on a day-to-day basis. He has authority to halt project activities for safety reasons.

- WESTON will designate certified Site Safety Coordinators (SSC) for on-site activities during completion of the abandonment activities. The SSCs will plan and supervise specific safety activities at RMA in close coordination and in compliance with policies established by the Safety Officer and this Safety Plan. The SSCs have the authority to halt on-site operations in the case of safety violations.

8.4 POTENTIAL CONTAMINANTS

The following compounds have been identified in monitoring wells at the RMA.

Aldrin/Dieldrin
Dicyclopentadiene (DCPD)
Dibromochloropropane (DBCP)
Diisopropylmethylphosphonate (DIMP)
Endrin
Chloroform
1,2-Dichloroethane
1,1-Dichloroethene
T-1,2-Dichloroethene
1,1-Dichloroethane
Benzene
Chlorobenzene
DDT
DDE
Carbon Tetrachloride
Methylene Chloride
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Isodrin
Toluene
Ethylbenzene
M-xylene
O&P-xylene
Trichloroethene
Tetrachloroethene
1,4-Oxathiane
1,4-Dithiane
Arsenic
Mercury
Lead
Cadmium
Zinc
Hydrazine
Nitrosodimethylamine

Attachment 1 provides compound-specific information.

Information on contaminant concentrations in groundwater and soil are available in Contaminant Assessment Reports (CAR). These reports will be searched to determine soil and groundwater contaminant concentrations, air monitoring results, and any information concerning levels of protection previously used. A Work Location Personnel Protection and Safety evaluation form will be completed for each section. The procedures to be

followed and personnel protection equipment to be used in the section will be provided in this form. Mr. Elijah Jones (303-289-0194) may also be contacted for information concerning the work area. Work will be conducted section by section. This will preclude any confusion of hazards from section to section.

The South Plant, where phosgene and mustard gas were produced, contains mustard pits. This area also contains the hydrazine blending and storage area. This area is fenced and must be entered in Level B personnel protection due to the presence of nitrosodimethylamine. The explosive ordnance and chemical agent area is located in Section 32. The toxic storage area in Section 31 is fenced and locked. Special arrangements must be made to enter this area. Section 36 is the initial disposal area and should not be entered casually. The North Plants were the nerve agent production facility. Basins A through F in Sections 25 and 35 were used for waste.

8.5 PERSONNEL PROTECTION REQUIREMENTS

8.5.1 Protective Clothing

Well search activities will be performed in a modified Level D personnel protection. The modified Level D protection consists of the following:

- Steel toe/shank boots.
- Cotton cloth coveralls or other designated work uniform.
- Hard hat (if bump or overhead hazards are present).

- o Eye protection.
- o Cotton or leather work gloves (as required).

No contact with waste is anticipated during this operation. The well search will consist of a visual search as well as non-intrusive geophysical surveys.

Well abandonment will commence in Level D personnel Protection when currently available monitoring data indicate the well is not located in a contaminant plume. Wells will be considered to be in a contaminant plume if contaminant concentrations exceed one of the following:

- o Two times the background concentration, or
- o Concentrations in the water exceed the fresh water acute exposure limit listed in Attachment 1.

Level D protection consists of the following:

- o Steel toe/shank boots
- o Disposable latex boot covers
- o Cotton cloth coveralls or other designated work uniform
- o Hard hat
- o Eye protection (safety glasses or splash shield)
- o Latex surgical gloves
- o Cotton or leather work gloves

When the potential exists for contact with contaminants, well abandonment operations will be conducted in Level C personnel protection, if possible. The determination of the adequacy of Level C protection will consider the contaminant(s) of concern, possible breathing zone concentrations, availability of air purifying cartridges to remove the contaminant, warning properties of the contaminant and ability of real-time monitoring instruments to detect the contaminant. Level C personnel protection consists of the following:

- o Level D protective equipment
- o Full face air purifying respirator
- o Organic vapor/high efficiency filter combination
- o Nitrile/butyl outer gloves
- o Saranex outer coveralls

The procedures for respirator use are as follows:

- o The use and maintenance of all respirators will be in accordance with the manufacturer's instructions. Only NIOSH-approved respirators will be used. One respirator will be provided for each employee. The SSC will monitor the respirator maintenance and cleaning. New canisters should be used daily or at any notice of a breakthrough odor. Disposal of spent canisters will be per manufacturer's recommendations under direction of the SSC.

- o No one will use a respirator in the field without prior qualitative fit testing and training by a qualified instructor.

- o Users will clean respirators after use in an area where no hazardous material was known or suspected of being released during activities. Users will clean respirators weekly before the final return of their equipment. Instruction in the care and maintenance of the respirators will be mandatory for all personnel. (See Attachment 3 for cleaning, care, and storage instructions.)

- o When not in use, respirators will be stored in a clean container at a designated location.

- o Users will daily inspect canister respirators for worn or defective parts.

- o Surveillance by the SSC will ensure that respirators are properly used and maintained.

- o Beards will not be worn by anyone in work areas where respiratory protection is required since beards prevent proper face sealing of respirators.

- o No materials will be used to "enhance" or "improve" respirator face seal (i.e., petroleum jelly, etc.).

- o Contact lenses and glasses will not be worn when respiratory protection is required.

- o Contact lenses will not be worn on site.

- o Escape packs will be worn by personnel entering the exclusion zone if there is the possibility of release that would result in an IDLH concentration.

The breathing zone will be continuously monitored with two HNu photoionization detectors (10.2 and 11.7 eV bulb) and an OVA-128 flame ionization detector. If breathing zone readings consistently exceed 5 units on either the HNu or OVA, Level B protection

will be used. Level B protection will also be used if high concentrations of contaminants are expected, the contaminant concentration in the well to be abandoned is unknown, respirator cartridges will not remove the contaminant, or monitoring instruments cannot detect the contaminant. The hydrazine blending and storage area will be Level B. Level B will consist of the following:

- Self-contained breathing apparatus (MSHA/NIOSH approved) or tether line, airline respirator equipment
- Steel toe/shank boots
- Latex boot covers
- Cotton cloth coveralls (inner)
- Saranex, one-piece, protective coveralls (outer)
- Latex surgical inner glove
- Nitrile glove
- Butyl outer glove
- Hard hat
- Splash shield (optional)

The levels of protection selected for the various tasks involved in this project are appropriate for the anticipated hazards. If site conditions warrant an upgrade in protection, the SSC will make the appropriate decision.

8.5.2 Additional Safety Equipment

Extra safety equipment will be located in the sampling vehicle and at the site. This equipment will include the following items:

- Hard hats
- Respirators (full-face)
- Respirator cartridges
- Disposable protective suits
- Boots
- Ear protectors
- Butyl/neoprene gloves
- Work gloves (leather)

Additional equipment that will be kept at active work sites will include:

- First aid kit
- Fire extinguishers (ABC Dry Chemical, 1 pound)
- Disposable hand towels
- Paper towels
- Buckets
- Garbage bags for contaminated/discarded materials
- Emergency eye wash

8.5.3 Monitoring Equipment

The monitoring equipment of the well abandonment work will consist of an HNu photoionization detectors with a 10.2 eV lamp and one with an 11.7 eV lamp and an OVA-128 flame ionization detector. An operational and calibration check will be performed on each instrument daily. Calibration will be performed daily or after repair.

Additional monitoring equipment that will be available is:

- Nerve agent Monitor
- Mustard gas Monitor
- Combustible Gas Indicator
- Oxygen Meter

8.5.4 Communications

All field search teams and drill rigs will be equipped with a two-way radio for communication. In addition, the rig geologist, Site Safety Coordinator, and field manager will have a radio. The base station for the radios will be located in the WESTON office

trailer on site. Personnel will have access to a telephone on site for notification of the Fire Department/Ambulance in an emergency.

8.5.5 Training

All personnel who will work at the RMA site will have received general and site-specific safety training prior to going into the exclusion zone. WESTON's Director of Corporate Health and Safety is responsible for guaranteeing that the training course meets the requirements of 29 CFR 1910.120. The SSC will be responsible for verifying that all site workers have met safety training requirements and appropriate safety procedures are practiced during field activities.

Site-specific training and orientation will be conducted by the Site Safety Coordinator. Topics include:

- Use, maintenance, and decontamination of protective clothing.
- Use, maintenance, and decontamination of safety equipment.
- Corporate safety policies and procedures, including a discussion of medical examinations and performing respirator-fit testing prior to visiting the site, as prescribed under 29 CFR 1910.120.
- Site-specific procedures, points of contact, and site requirements.
- Emergency response.
- Review of safety aspects of sampling operations.
- Potential toxic hazards on-site.
- Hazardous compounds that may be encountered.
- Rocky Mountain Arsenal training/orientation for site specific hazards.
- Instrument use.

Attachment 4 contains an example of the work location Personnel Protection and Safety Evaluation Form which will be read and signed by all site workers.

8.5.6 Medical Monitoring Program

All personnel engaged in work at the RMA will participate in the medical monitoring program which certifies them to perform work and provide a baseline assessment. Physician certification will be required for all personnel using respiratory protection.

8.6 DECONTAMINATION OF PERSONNEL AND EQUIPMENT

Personnel contact with contaminants will be minimized as far as can be reasonably achieved. Personnel and equipment that have been in contact with contaminated materials may carry residual contamination. Despite protective clothing, equipment, and good work practices, decontamination may also be necessary to prevent personnel exposure and migration of contaminants. Decontamination will be done under the direction of the Site Safety Coordinator. The work location will be divided into three distinct work zones. The work zones are as follows:

Zone 1: Exclusion Zone -- The zone where contamination does or could exist. All personnel entering this one must wear the level of protective clothing specified for that work area.

Zone 2: Contamination Reduction Zone -- Provides a transition zone between the Exclusion Zone and the Support Zone to prevent the spread of contaminants from the Exclusion Zone. Decontamination is performed in this zone.

Zone 3: Support Zone -- Area of work site considered to be non-contaminated located upwind of the Exclusion Zone. This is a storage area for support equipment and provides a point of personnel access and traffic control to the Exclusion Zone.

A diagram of the minimum Level C and B decontamination layout is provided in Attachment 4, showing the required decontamination stages, should these levels of protection become necessary. The following general guidelines will be used in the development of decontamination procedures

- o The level of decontamination will depend on the nature and magnitude of contamination, and the type of protective clothing.

- o Personnel assisting in the decontamination activities will be attired in clothing to protect them from contamination released during the decontamination process.

- o Under emergency conditions, decontamination procedures will be omitted and lifesaving measures initiated without delay if:

    - decontamination activities could aggravate or cause more serious health effects, or if

    - prompt lifesaving first aid and/or medical treatment is required.

Personnel decontamination for Level D protection will consist of washing hands and face with soap and water after leaving the exclusion zone and before eating or drinking.

Personnel in Level B protection will wash their outer gloves and boots with a solution of trisodiumphosphate, Alconox, and water followed by a tap water rinse. Personnel will also wash their hands and face after removing all protective clothing.

All personnel working at the RMA will change from personal clothing to company-supplied clothing prior to performing any work. Prior to leaving RMA each evening, personnel will shower and change. Company-supplied clothing is not to be worn off the RMA.

All disposable coveralls, gloves, booties, etc. will be placed in drums at the well site, labeled, and given to the hazardous waste contractor at RMA. All waste from the exclusion zone will be considered hazardous waste and kept separate from other waste.

Drill rigs will be decontaminated by moving them to the decontamination pad and cleaning with high pressure hot water. The key to the decontamination pad must be obtained from R. L. Stoller Assoc. Sludge is not to be flushed into the sump. Liquid is to be transferred to the tank at the decontamination pad. The R. L. Stoller representative may be contacted at 289-6325. Personnel performing the decontamination will be dressed in Level C attire with a face shield to protect from splashback.

8.7 AUDITS

Audits of the Health and Safety Program at the RMA will be performed quarterly, at a minimum by the Denver Office Regional Safety Officer or his designee. In addition, the WESTON Corporate Health and Safety Director or his designee will audit the RMA Health and Safety Program annually, at a minimum. The Site Safety Coordinator (SSC) will be responsible for assuring the Health and Safety Plan is followed on a daily basis.

8.8 CONTINGENCY PLAN

The purpose of this section is to advise WESTON and subcontractor personnel of contingency actions to be taken in the event of accidental exposure or injury accidents. In all cases, the Site Safety Coordinator will be notified immediately. The following telephone numbers will be used to report an emergency and to request on-site assistance. Emergency ambulance and post security must be notified as soon as possible after an accident or incident occurs. These numbers should be posted at the work location and in all field trailers.

o	Safety Office	(303) 289-0338
o	Fire Department/Ambulance	(303) 289-0223
o	Security/Desk Sgt.	(303) 289-0364 -0372
o	Post Contact	Dr. Trautmann (303) 289-0335

Accident and incident reporting procedures are listed as follows. Contact shall be made in the order indicated once the ambulance and security have been notified.

1. Call Ms. Alma Harris, Army Safety Office, at (303) 289-0338.
2. Call Mr. Dave Parks, Contracting Officer, at (303) 289-0164 to report accident/incident; give information outlined below.

3. Call Mr. George Crawford, WESTON Corporate Safety Officer, at (215) 430-7406; Mr. William Lynott, WESTON Program Manager, or Mr. Mark Hutson, Task Manager, at (303) 980-6800.

4. Call Dr. B. Trautmann at (303) 289-0335.

5. Complete written Accident/Incident Report, using format in Attachment 2.

6. Complete supplementary written Accident/Incident Report as directed by Mr. George Crawford.

Attachment 2 also contains the Rocky Mountain Arsenal SOP for emergency response. The following information is to be supplied.

- Name, organization, telephone number, and location of contractor.
- Name and title of person(s) reporting.
- Date and time of accident/incident.
- Location of accident/incident, i.e., building number, facility name.
- Summary of accident/incident, giving pertinent details including type of operation ongoing at time of accident.
- Suspected/known cause of accident/incident.
- Number, names, and titles of people involved, witnesses, etc.
- Casualties (fatalities, disabling injuries).
- Details of any existing chemical hazard of contamination.
- Estimated property damage, if applicable.
- Nature of damage; effect on contract schedule.
- Action taken by contractor to ensure safety and security.
- Other damage or injuries sustained (public or private).

A written report should be completed within 24 hours. If a chemical agent is suspected, personnel will be taken to Fitzsimmons Army Medical Center. If no chemical agent is involved, personnel will be taken to Aurora Presbyterian Hospital. Directions to these facilities are provided in Attachment 4. Attachments 5 and 6 provide a first aid guide for accidents frequently encountered at work locations and information on heat and cold

stress. Attachment 7 provides a copy of the subontractor's Health and Safety Agreement which is to be read and signed by the subcontractor.

ATTACHMENT 1

CHEMICAL REFERENCES

ALDRIN/DIELDRIN

Summary

Aldrin degrades to dieldrin, which is very persistent in the environment. Both pesticides are carcinogenic in rats and mice and are teratogenic and reproductive toxicants. Aldrin and dieldrin cause liver toxicity and central nervous system abnormalities following chronic exposure. Both are also acutely toxic, with oral LD_{50} values of about 50 mg/kg. Both pesticides are very toxic to aquatic organisms and have been associated with large-scale kills of terrestrial wildlife in treated areas.

Background Information

Dieldrin is the 6,7-epoxide of aldrin and is readily obtained from aldrin under normal environmental conditions and by metabolism in animals.

CAS Number: Aldrin: 309-00-2
Dieldrin: 60-57-1

Chemical Formula: Aldrin: $C_{12}H_8Cl_6$
Dieldrin: $C_{12}H_8Cl_6O$

IUPAC Name:
Aldrin: 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-exo-dimethanonaphthalene
Dieldrin: 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,exo-1,4:5,8-dimethanonaphthalene

Chemical and Physical Properties

Molecular Weight: Aldrin: 365
Dieldrin: 381

Melting Point: Aldrin: 104°C
Dieldrin: 176 °C

Solubility in Water: Aldrin: 20/ ug/liter at 25°C
Dieldrin: 200 ug/liter at 25°C

Solubility in Organics: Soluble in most organic solvents

Log Octanol/Water Partition Coefficient: No data found; probably greater than 5 for both chemicals

Vapor Pressure: Aldrin: 2.31×10^{-5} mm at 20°C
Dieldrin: 2.8×10^{-6} mm at 20°C

Transport and Fate

Aldrin evaporates rapidly from aquatic environments and also probably from soil. Photolysis probably occurs in the atmosphere after volatilization. Adsorption, especially by organic materials, is also an important fate process for this chemical. Aldrin is bioconcentrated by aquatic organisms by a factor of 10^3 to 10^4. Biotransformation by aquatic organisms and biodegradation are also important fate processes.

The primary product of aldrin degradation is its epoxide, dieldrin. Photolysis of aldrin also produces small amounts of photoaldrin, photodieldrin, and a polymerization product. Dieldrin is considered to be at least as toxic as aldrin and is quite persistent in the environment. Therefore, transformation of aldrin represents only a change of state and not detoxification of the chemical.

Dieldrin is one of the most persistent of the chlorinated hydrocarbons. Volatilization and possibly subsequent photolysis to photodieldrin are important transport and fate processes from surface water and probably from soil. Adsorption to sediments, especially organic materials, and bioaccumulation are also important in removing dieldrin from water. Biotransformation and biodegradation of dieldrin occur very slowly but may be the final fate processes in sediment.

Health Effects

Both aldrin and dieldrin are carcinogens, causing increases in a variety of tumors in rats at low but not at high doses and producing a higher incidence of liver tumors in mice. the reason for this reversed dose-response relationship is unclear. Neither appears to be mutagenic when tested in a number of systems. Aldrin and dieldrin are both toxic to the reproductive system and teratogenic. Reproductive effects include decreased fertility, increased fetal death, and effects on gestation; while teratogenic effects include cleft palate, webbed foot, and skeletal anomalies. Chronic effects attributed to aldrin and dieldrin include liver toxicity and central nervous system abnormalities. Both chemicals are acutely toxic; the oral LD_{50} is around 50 mg/kg, and the dermal LD_{50} is about 100 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

Freshwater

Acute toxicity:	Aldrin: 3.0 ug/liter Dieldrin: 2.5 ug/liter
Chronic toxicity:	Aldrin: No available data Dieldrin: 0.0019 ug/liter

Saltwater

Acute toxicity: Aldrin: 1.3 ug/liter
Dieldrin: 0.71 ug/liter

Chronic toxicity: Aldrin: No available data
Dieldrin: 0.0019 ug/liter

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations in water are:

Risk	Aldrin Concentration	Dieldrin Concentration
10^{-5}	0.74 ng/liter	0.71 ng/liter
10^{-6}	0.074 ng/liter	0.071 ng/liter
10^{-7}	0.0074 ng/liter	0.0071 ng/liter

CAG Unite Risk (U.S. EPA): Aldrin: 11.4 $(mg/kg/day)^{-1}$
Dieldrin: 30.4 $(mg/kg/day)^{-1}$

ACGIH Threshold Limit Value:* 0.25 mg/m3 TWA
0.75 mg/m^3 STEL

OSHA Standard (air):* 250 ug/m^3 TWA

* Applies to both aldrin and dieldrin.

ARSENIC

Summary

Arsenic is a metal that is present in the environment as a constituent of organic and inorganic compounds; it also occurs in a number of valence states. Arsenic is generally rather mobile in the natural environment, with the degree of mobility dependent on its chemical form and the properties of the surrounding medium. Arsenic is a human carcinogen; it causes skin tumors when it is ingested and lung tumors when it is inhaled. Arsenic compounds are teratogenic and have adverse reproductive effects in animals. Chronic exposure to arsenic is associated with polyneuropathy and skin lesions. It is acutely toxic to some early life stages of aquatic organisms at levels as low as 40 ug/liter.

Background Information

Arsenic can be found in the environment in any of four valence states (-3, 0, +3 and +5) depending on the pH, Eh, and other factors. It can exist as either inorganic or organic compounds and often will change forms as it moves through the various media. The chemical and physical properties depend on the state of the metalloid. Only the properties of metallic arsenic have been listed; properties of other arsenic compounds are often quite different.

CAS Number: 7440-38-2

Chemical Formula: As

IUPAC Name: Arsenic

Chemical and Physical Properties

Atomic Weight: 74.91

Boiling Point: 613°C

Melting Point: 817°C

Specific Gravity: 5.72 at 20°C

Solubility in Water: Insoluble; some salts are soluble.

Transport and Fate

In the natural environment, arsenic has four different oxidation states, and chemical speciation is important in determining arsenic's distribution and mobility. Interconversions of the +3 and +5 states as well as organic complexation, are the most important. Arsenic is generally quite mobile in the environment. In the aquatic environment, volatilization is important when biological activity or highly reducing conditions is an important fate for the chemical. Arsenic is metabolized to organic arsenicals by a number of organisms; this increases arsenic's mobility in the environment. Because of its general mobility, arsenic tends to cycle through the environment. Its ultimate fate is probably the deep ocean, but it may pass through numerous stages before finally reaching the sea.

Health Effects

Arsenic has been implicated in the production of skin cancer in humans. There is also extensive evidence that inhalation of arsenic compounds causes lung cancer in workers. Arsenic compounds cause chromosome damage in animals, and humans exposed to arsenic compounds have been reported to have an elevated incidence of chromosome aberrations. Arsenic compounds have been reported to be teratogenic, fetotoxic, and embryotoxic in several animal species, and an increased incidence of multiple malformations among children born to women occupationally exposed to arsenic has been reported. Arsenic compounds also cause noncancerous, possibly precancerous, skin changes in exposed individuals. Several cases of progressive polyneuropathy involving motor and sensory nerves and particularly affecting the extremities and myelinated long-axon neurons have been reported in individuals occupationally exposed to inorganic arsenic. Polyneuropathies have also been reported after the ingestion of arsenic-contaminated foods.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

Freshwater

Acute toxicity: 440 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 508 ug/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of arsenic in water are:

Risk	Concentration
10^{-5}	22 ng/liter
10^{-6}	2.2 ng/liter
10^{-7}	0.22 ng/liter

CAG Unit Risk (U.S. EPA): 15 $(mg/kg/day)^{-1}$

National Interim Primary Drinking Water Standard (U.S. EPA): 50 ug/liter

NIOSH Recommended Standard (air): 2 ug/m^3 TWA

OSHA Standard (air): 500 ug/m^3 TWA

ACGIH Threshold Limit Value: 200 ug/m^3 (soluble compounds, as As).

BENZENE

Summary

Benzene is an important industrial solvent and chemical intermediate. It is rather volatile, and atmospheric photooxidation is probably an important fate process. Benzene is a known human carcinogen, causing leukemia in exposed individuals. It also adversely affects the hematopoietic system. Benzene has been shown to be fetotoxic and to cause embryolethality in experimental animals. Exposure to high concentrations of benzene in the air causes central nervous system depression and cardiovascular effects, and dermal exposure may cause dermatitis.

CAS Number: 71-43-2

IUPAC Name: Benzene

Chemical Formula: C_6H_6

Chemical and Physical Properties

Molecular Weight: 78.12

Boiling Point: 80.1°C

Melting Point: 5.56°C

Specific Gravity: 0.879 at 20°C

Solubility in Water: 1,780 mg/liter at 25°C

Solubility in Organics: Miscible with ethanol, ether, acetic acid, acetone, chloroform, carbon disulfide, and carbon tetrachloride

Log Octanol/Water Partition Coefficient: 1.95-2.13

Vapor Pressure: 75 mm Hg at 20°C

Vapor Density: 2.77

Flash Point: -11.1°C

Transport and Fate

Volatilization appears to be the major transport process of benzene from surface waters to the ambient air, and atmospheric transport of benzene occurs readily (U.S. EPA 1979). Although direct oxidation of benzene in environmental waters is

unlikely, cloud chamber data indicate that it may be photooxidized rapidly in the atmosphere. Inasmuch as volatilization is likely to be the main transport process accounting for the removal of benzene from water, the atmospheric destruction of benzene is probably the most likely fate process. Values for benzene's log octanol/water partition coefficient indicate that adsorption onto organic material may be significant under conditions of constant exposure. Sorption processes are likely removal mechanisms in both surface water and groundwater. Although the bioaccumulation potential for benzene appears to be low, gradual biodegradation by a variety of microorganisms probably occurs. The rate of benzene biodegradation may be enhanced by the presence of other hydrocarbons.

Health Effects

Benzene is a recognized human carcinogen. Several epidemiological studies provide sufficient evidence of a causal relationship between benzene exposure and leukemia in humans. Benzene is a known inducer of aplastic anemia in humans, with a latent period of up to 10 years. It produces leukopenia and thrombocytopenia, which may progress to pancytopenia. Similar adverse effects on the blood-cell-producing system occur in animals exposed to benzene. In both humans and animals, benzene exposure is associated with chromosomal damage, although it is not mutagenic in microorganisms. Benzene was fetotoxic and caused embryolethality in experimental animals.

Exposure to very high concentrations of benzene [about 20,000 ppm (66,000 mg/m^3) in air] can be fatal within minutes. The prominent signs are central nervous system depression and convulsions, with death usually following as a consequence of cardiovascular collapse. Milder exposures can produce vertigo, drowsiness, headache, nausea, and eventually unconsciousness if exposure continues. Deaths from cardiac sensitization and cardiac arrhythmias have also been reported after exposure to unknown concentrations. Although most benzene hazards are associated with inhalation exposure, dermal absorption of liquid benzene may occur, and prolonged or repeated skin contact may produce blistering, erythema, and a dry, scaly dermatitis.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest concentrations of benzene known to cause toxic effects in aquatic organisms.

Freshwater

Acute toxicity: 5,300 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 5,100 ug/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of benzene in water are:

Risk	Concentration
10^{-5}	6.6 ug/liter
10^{-6}	0.66 ug/liter
10^{-7}	0.066 ug/liter

CAG Unit Risk (U.S. EPA): 2.0×10^{-2} $(mg/kg/day)^{-1}$

OSHA Standard (air): 30 mg/m^3 TWA
75 mg/m^3 Ceiling Level
150 mg/m^3 10-min Peak Level

ACGIH Threshold Limit Value: Suspected human carcinogen
30 mg/m^3 TWA
75 mg/m^3 STEL

CADMIUM

Summary

Cadmium is a metal that can be present in a variety of chemical forms in wastes or in the environment. Some forms are insoluble in water, but cadmium is relatively mobile in the aquatic environment. Cadmium is carcinogenic in animals exposed by inhalation and may also be in humans. It is uncertain whether it is carcinogenic in animals or humans exposed via ingestion. Cadmium is a known animal teratogen and reproductive toxin. It has chronic effects on the kidney, and background levels of human exposure are thought to provide only a relatively small margin of safety for these effects.

Background Information

Cadmium is a soft, bluish white metal that is obtained as a by-product from the treatment of the ores of copper, lead, and iron. Cadmium has a valence of +2 and has properties similar to those of zinc. Cadmium forms both organic and inorganic compounds. Cadmium sulfate is the most common salt.

CAS Number: 7440-43-9

Chemical Formula: Cd

IUPAC Name: Cadmium

Chemical and Physical Properties

Atomic Weight: 112.41

Boiling Point: 765°C

Melting Point: 321°C

Specific Gravity: 8.642

Solubility in Water: Salts are water soluble; metal is insoluble

Solubility in Organics: Variable, based on compound

Vapor Pressure: 1 mm Hg at 394°C

Transport and Fate

Cadmium is relatively mobile in the aquatic environment compared to other heavy metals. It is removed from aqueous media by complexing with organic materials and subsequently being adsorbed to the sediment. It appears that cadmium moves slowly through soil, but only limited information on soil transport is available. Cadmium uptake by plants is not a significant mechanism for depletion of soil accumulations but may be significant for human exposure.

Health Effects

There is suggestive evidence linking cadmium with cancer of the prostate in humans. In animal studies, exposure to cadmium by inhalation caused lung tumors in rats, and exposure by injection produced injection-site sarcomas and/or Leydig-cell tumors. An increased incidence of tumors has not been seen in animals exposed to cadmium orally, but four of the five available studies were inadequate by current standards.

The evidence from a large number of studies on the mutagenicity of cadmium is equivocal, and it has been hypothesized that cadmium is not directly mutagenic but impedes repair. Cadmium is a known animal teratogen and reproductive toxin. It has been shown to cause renal dysfunction in both humans and animals. Other toxic effects attributed to cadmium include immunosuppression (in animals), anemia (in humans), pulmonary disease (in humans), possible effects on the endocrine system, defects in sensory function, and bone damage. The oral LD_{50} in the rat was 225 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life (Proposed 1984)

Freshwater

Acute toxicity: $e^{\{1,30[\ln(\text{hardness})] - 3.92\}}$ ug/liter
Chronic toxicity: $e^{\{1,30[\ln(\text{hardness})] - 3.92\}}$ ug/liter

Saltwater

Acute toxicity: 38 ug/liter
Chronic toxicity: 12 ug/liter

Human Health

Criterion: 10 ug/liter

CAG Unit Risk for inhalation exposure (U.S. EPA): 6.1 $(mg/kg/day)^{-1}$

Interim Primary Drinking Water Standard (U.S. EPA): 10 ug/liter

NIOSH Recommended Standards: 40 ug/m^3 TWA
200 ug/m^3/15 min Ceiling Level

OSHA Standard (air): 200 ug/m^3 TWA
600 ug/m^3 Ceiling Level

ACGIH Threshold Limit Value: 50 ug/m^3 TWA

CARBON TETRACHLORIDE

Summary

Carbon tetrachloride is used as a industrial solvent and chemical intermediate. It is an animal carcinogen, causing liver tumors in mice, rats, and hamsters. Carbon tetrachloride also causes liver and kidney damage in animals and humans.

Chemical Formula: CCl_4

IUPAC Name: Tetrachloromethane

Important Synonyms and Trade Names: Tetrachoromethane, perchloromethane

Chemical and Physical Properties

Molecular Weight: 153.8

Boiling Point: 76.7°C

Melting Point: 22.9°C

Specific Gravity: 1.59 at 20°C (liquid)
5.3 vapor (gas) specific gravity

Solubility in Water: 800 mg/liter

Solubility in Organics: Miscible with alcohol, benzene, chloroform, ether, and carbon disulfide

Log Octanol/Water Partition Coefficient: 2.64

Vapor Pressure: 90 mm Hg at 20°C

Vapor Density: 5.32

Transport and Fate

Carbon tetrachloride has a high vapor pressure and therefore volatilizes rapidly into the atmosphere from surface water and probably from soil. It is relatively soluble in water and therefore would be expected to be transported in groundwater. Because of its high specific gravity, it may move independently from the groundwater as a nonaqueous phase liquid.

Health Effects

Carbon tetrachloride was carcinogenic in mice, rats, and hamsters; in all cases liver tumors were induced. In addition, mice also displayed a high incidence of tumors of the adrenal gland. Studies discussed by EPA (1980) on the mutagenic and teratogenic effects of carbon tetrachloride and its impact on reproduction are inconclusive. Carbon tetrachloride also causes both liver and kidney damage in animals and humans. One study in which guinea pigs were repeatedly exposed to carbon tetrachloride vapor for several months provided evidence of damage to the optic nerve and degeneration of the myelin sheath of the sciatic nerve.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to cause toxicity in aquatic organisms.

Freshwater

Acute toxicity: 35,200 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 50,000 ug/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to carbon tetrachloride at various concentrations in water are:

Risk	Concentration
10^{-5}	4.0 ug/liter
10^{-6}	0.4 ug/liter
10^{-7}	0.04 ug/liter

CAG Unit Risk (U.S. EPA): 1.3×10^{-1} $(mg/kg/day)^{-1}$

OSHA Standard (air): 10 ppm TWA
25 ppm Ceiling Level

ACGIH Threshold Limit Value: 5 ppm Skin.

CHLOROBENZENE

Summary

Chlorobenzene is used as a solvent and as a raw material in chemical manufacturing. It is persistent in the environment and can be adsorbed to organic material in soil. Chlorobenzene may cause liver tumors in male mice. Animals exposed to chlorobenzene have exhibited liver and kidney damage. Chlorobenzene is not very toxic to aquatic organisms; none of the LC_{50} values are less than 10 mg/liter.

CAS Number: 108-90-7

Chemical Formula: C_6H_5Cl

IUPAC Name: Chlorobenzene

Important Synonyms and Trade Names: Monochlorobenzene, benzene chloride, phenyl chloride

Chemical and Physical Properties

Molecular Weight: 112.6

Boiling Point: 131°C

Melting Point: -46°C

Specific Gravity: 1.11 at 20°C (liquid)

Solubility in Water: 500 mg/liter

Solubility in Organics: soluble in alcohol, benzene, chloroform, ether, and carbon tetrachloride

Log Octanol/Water Partition Coefficient: 2.83

Vapor Pressure: 8.8 mm Hg at 20°C

Vapor Density: 3.88

Henry's Law Constant: 3.56×10^{-3} atm m^3/mole at 25°C

Flash Point: 28°C

Transport and Fate

Chlorobenzene is probably removed from surface water primarily by volatilization, although adsorption and bioaccumulation may also be factors. Monochlorobenzene would be expected to move slowly in soil because of its high octanol/water partition coefficient and consequent adsorption to soil organic material.

Health Effects

A study of the carcinogenicity of chlorobenzene was recently completed by the National Toxicology Program and preliminary results show that chlorobenzene caused neoplastic nodules in the liver of male rats but was not carcinogenic in female rats or in mice.

Occupational studies suggest that chronic exposure to monochlorobenzene vapor may cause blood dyscrasia, hyperlipidemia, and cardiac dysfunction in humans. Like many organic solvents, monochlorobenzene is a central nervous system depressant in overexposed humans, but no chronic neurotoxic effects have been reported. animals exposed to chlorobenzene have exhibited liver and kidney damage and atrophy of the seminiferous tubules in the testes. The oral LD_{50} value for rats was 2910 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria.

Human Health

Health criterion: 488 ug/liter
Organoleptic criterion: 20 ug/liter

OSHA Standard (air): 350 mg/m^3 TWA

ACGIH Threshold Limit Value: 350 mg/m^3 TWA - 75 ppm.

CHLOROFORM

Summary

Chloroform (trichloromethane) is often produced during the chlorination of drinking water and thus is a common drinking water contaminant. It is volatile in surface waters and is not likely to be persistent in the environment. Chloroform caused an increase in kidney epithelial tumors in rats and in hepatocellular carcinomas in mice. In addition, there is suggestive evidence from epidemiological studies that exposure to chloroform and other trihalomethanes is associated with an increased incidence of bladder tumors in humans. Other toxic effects of chloroform include central nervous system depression; eye, skin, and gastrointestinal irritation; and damage to the liver, heart, and kidney.

CAS Number: 67-66-3

Chemical Formula: $CHCl_3$

IUPAC Name: Trichloromethane

Chemical and Physical Properties

Molecular Weight: 119.38

Boiling Point: 61.7°C

Melting Point: -63.5°C

Specific Gravity: 1.4832 at 20°C (liquid)

Solubility in Water: 8,200 mg/liter at 20°C

Solubility in Organics: soluble in acetone; miscible with alcohol, ether, benzene, and ligroin

Log Octanol/Water Partition Coefficient: 1.97

Vapor Pressure: 150.5 mm Hg at 20°C

Vapor Density: 4.12

Transport and Fate

Volatilization into the atmosphere is the major transport process for removal of chloroform from aquatic systems. Once in the troposphere, chloroform is attacked by hydroxyl radicals with the subsequent formation of phosgene ($COCl_2$) and possibly chlorine oxide (ClO) radicals. Neither of these reaction products is likely to persist;

phosgene is readily hydrolyzed to hydrochloric acid and carbon dioxide. Reaction with hydroxy radicals is thought to be the primary environmental fate of chloroform. However, chloroform that remains in the troposphere may return to earth in precipitation or adsorbed on particulates, and a small amount may diffuse upward to the stratosphere where it photodissociates via interaction with ultraviolet light.

Photolysis, hydrolysis, and sorption do not appear to be significant environmental fate processes for chloroform. However, sorption processes may have some importance as a removal mechanism in groundwater and soil. The log octanol/water partition coefficient6 indicates that this compound may bioaccumulate under conditions of constant exposure. Studies with marine organisms provide evidence for only weak to moderate bioaccumulation. Although chloroform is somewhat lipophilic and tends to be found at higher concentrations in fatty tissues, there is no evidence for biomagnification in aquatic food chains.

Health Effects

Chronic administration of chloroform by gavage is reported to produce a dose-related increase in the incidence of kidney epithelial tumors in rats and a dose-related increase in the incidence of hepatocellular carcinomas in mice. Epidemiological studies suggest that higher concentrations of chloroform and other trihalomethanes in water supplies may be associated with an increased frequency of bladder cancer in humans. However, these results are not sufficient to establish causality. An increased incidence of fetal abnormalities was reported in offspring of pregnant rats exposed to chloroform by inhalation. Oral doses of chloroform that caused maternal toxicity produced relatively mild fetal toxicity in the form of reduced birth weights. There are limited data suggesting that chloroform has mutagenic activity in some test systems. However, negative results have been reported for bacterial mutagenesis assays.

Humans may be exposed to chloroform by inhalation, ingestion, or skin contact. Toxic effects include local irritation of the skin or eyes, central nervous system depression, gastrointestinal irritation, liver and kidney damage, cardiac arrhythmia, ventricular tachycardia, and bradycardia. Death from chloroform overdosing can occur and is attributed to ventricular fibrillation. Chloroform anesthesia can produce delayed death as a result of liver necrosis.

Exposure to chloroform by inhalation, intragastric administration, or intraperitoneal injection produces liver and kidney damage in laboratory animals. The oral LD_{50} and inhalation LC_{LO} values for the rat are 908 mg/kg and 39,000 mg/m^3 per 4 hours, respectively.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria.

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of chloroform in water are:

Risk	Concentration
10^{-5}	1.90 ug/liter
10^{-6}	0.19 ug/liter
10^{-7}	0.019 ug/liter

CAG Unit Risk (U.S. EPA): 8.1×10^{-2} $(mg/kg/day)^{-1}$

DDT

Summary

DDT is an organochlorine pesticide, which together with its metabolites, is very persistent in the environment. DDT, DDE, and DDD have been shown to be carcinogenic in mice. They primarily cause liver tumors, but they also increase the incidence of lung tumors and lymphomas. In addition, DDT is a reproductive toxin. Chronic exposure can damage the central nervous system and liver. DDT and other organochlorine pesticides are highly toxic to aquatic organisms and are responsible for the decreased reproductive success of many bird species.

Background Information

Technical DDT is a mixture containing 65-89% p, p'-DDT, 15-20% o,p'-DDT, up to 4% p,p'-DDD, and traces of other materials. Metabolites of DDT include p,p'-DDE and o,p'-DDD. The DDT isomers and metabolites are usually found together and generally have similar properties; therefore, they will be considered together. Where differences occur the specific isomer will be identified. DDT will be used to refer to the combination of technical material and metabolites. Specific DDT isomers will be identified as such.

CAS Number:
- p,p'-DDT: 50-29-3
- o,p'-DDT: 789-02-6
- p,p'-DDD: 72-54-8
- o,p'-DDD: 53-19-0
- p,p'-DDE: 72-55-9

Chemical Formula:
- p,p'- and o,p'-DDT: $C_{14}H_9Cl_5$
- p,p'- and o,p'-DDD: $C_{13}H_{10}Cl_4$
- p,p'- and o,p'-DDE: $C_{14}H_8Cl_4$

IUPAC Name:
- p,p'-DDT: 1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane
- o,p'-DDT: 1,1,1-Trichloro-2-(2-chlorophenyl)-2-(4-chlorophenyl)ethane
- p,p'-DDD: 1,1-Dichloro-2,2-bis(4-chlorophenyl)-ethane
- o,p'-DDE: 1,1-Dichloro-2,2-bis(4-chlorophenyl)-ethene

Important Synonyms and Trade Names:
- DDT: Dichlorodiphenyltrichloroethane, dicophane, chlorophenothane, Gesarol, Neocid
- p,p'-DDD: TDE, Rothane

Chemical and Physical Properties

Molecular Weight: o,p- and p,p'-DDT: 354.5
DDD: 320
DDE: 318

Boiling Point: DDT: 260°C

Melting Point: DDT: 109°C
DDD: 112°C
DDE: 90°C

Solubility in Water: p,p'-DDT: 5.5 ug/liter
o,p'-DDT: 26 ug/liter
p,p'-DDD: 20 ug/liter
DDE: 14 ug/liter

Solubility in Organics: DDT: soluble in acetone, benzene, cyclohexanane, morpholine, pyridine, and dioxane

Log Octanol/Water Partition Coefficient:

DDT: 4.98
p,p'-DDT: 3.98
p,p'-DDD: 5.99
o,p'-DDD: 6.08
DDE: 5.69

Vapor Pressure:

p,p'-DDT: 1.9×10^{-7} mm Hg at 25°C
p,p'-DDT: 7.3×10^{-7} mm Hg at 30°C
o,p'-DDT: 5.5×10^{-6} mm Hg at 30°C
p,p'-DDD: 1.0×10^{-6} mm Hg at 30°C
o,p'-DDD: 1.9×10^{-6} mm Hg at 30°C
-DDE: 6.5×10^{-6} mm Hg at 20°C

Transport and Fate

DDT and it metabolites are very persistent in the environment. Volatilization is probably the most important transport process from soil and water for p,p'-DDT and o,p'-DDT, as evidenced by the ubiquitous nature of DDT in the environment.

Sorption and bioaccumulation are the most important transport processes for the DDT isomers. Although it only occurs slowly, the ultimate fate process for p,p'-DDT, o,p'-DDT, and DDD is biotransformation to form bis (2-chlorophenyl)methanone (DDCO). Indirect photolysis may also be important for p,p'-DDT and o,p'-DDT in aquatic environments. For DDE, direct photolysis is the most important ultimate fate process in the environment although biotransformation may also be important.

Health Effects

DDT, DDE, and DDD have been shown to be carcinogenic to mice, primarily causing liver tumors, but also causing lung tumors and lymphomas. DDT does not appear to be mutagenic, but it has caused chromosomal damage. There is no evidence that DDT is a teratogen; but it is a reproductive toxin, causing reduced fertility, reduced growth of offspring, and fetal mortality.

Chronic exposure to DDT causes a number of adverse effects, especially to the liver and central nervous system (CNS). DDT induces various microsomal enzymes and therefore probably affects the metabolism of steroid hormones and exogenous chemicals. Other effects on the liver include hypertrophy of the parenchymal cells and increased fat deposition. In the CNS, exposure to DDT cause behavioral effects such as decreased aggression and decreased conditional reflexes. Acute exposure to large doses or chronic exposure to lower doses causes seizures. The oral LD_{50} is between 113 and 450 mg/kg for the rat and is generally higher for other animals.

DDT, DDD, and DDE are bioconcentrated and stored in the adipose tissues of most animals.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

DDT: Freshwater

Acute toxicity: 1.1 ug/liter
Chronic toxicity: 0.001 ug/liter

Saltwater

Acute toxicity: 0.13 ug/liter
Chronic toxicity: 0.001 ug/liter

DDD and DDE:

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to be toxic in aquatic organisms.

Freshwater

Acute toxicity:	DDD: 0.6 ug/liter
	DDE: 1050 ug/liter
Chronic toxicity:	DDD & DDE: No available data

Saltwater

Acute toxicity:	DDD: 3.6 ug/liter
	DDE: 14 ug/liter
Chronic toxicity:	DDD & DDE: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of DDT in water are:

Risk	Concentration
10^{-5}	0.24 ng/liter
10^{-6}	0.024 ng/liter
10^{-7}	0.0024 ng/liter

CAG Unit Risk (U.S. EPA): 0.34 $(mg/kg/day)^{-1}$

OSHA Standard (air): 1 mg/m^3 TWA

ACGIH Threshold Limit Value: 1 mg/m^3 TWA

DIBROMOCHLOROPROPANE

Summary

Dibromochloropropane (DBCP) was formerly used as a soil fumigant and nematocide. It has been found to be carcinogenic in mice and rats. It causes mammary tumors (in female rats only) and forestomach tumors when administered orally, and nasal, tongue, and lung tumors when given by inhalation. Men occupationally exposed to DBCP had abnormally low sperm counts. Animals studies have shown that dibromochloropropane has adverse effects on the liver, kidneys, and blood cells.

CAS Number: 96-12-8

Chemical Formula: $C_3H_5Br_2Cl$

IUPAC Name: 1,2-Dibromo-3-chloropropane

Important Synonyms and Trade Names: DBCP, Fumazone, Nemagon

Chemical and Physical Properties

Molecular Weight: 236.36

Boiling Point: 196°C

Melting Point: 6°C

Specific Gravity: 2.093 at 14°C

Solubility in Water: Slightly soluble (probably 5-10 g/liter)

Solubility in Organics: Miscible with oils, dichloropropane, and isopropyl alcohol

Vapor Pressure: 0.8 mm Hg at 21°C

Transport and Fate

There was no information available on the transport and fate of 1,2-dribromo-3-chloropropane (DBCP) at the time of this review. However, there is some information on the transport and fate of structurally similar compounds that may be relevant to the environmental fate of DBCP.

1,2,3-Trichloropropane was found to have a half-life of 51 minutes in stirred water, suggesting volatilization of DBCP from water could be significant. However, DBCP is considerably heavier than 1,2,3-trichloropropane and thus somewhat less likely to volatilize. The log octanol/water partition coefficient, 2.28 of 1,2-dichloropropane4 suggests that it will readily adsorb to organic components of soils and sediments and, therefore, be transported in dust and suspended solids. The tendency of brominated aliphatics to have higher log octanol/water portion coefficients than chlorinated aliphatics suggest DBCP will adsorb to a greater degree than 1,2-dichloropropane. Because of its water solubility, density, and low vapor pressure, DBCP is a likely groundwater contaminant. Its high density suggests that it would settle to the bottom of a contaminant plume and ultimately to the bottom of the aquifer.

Based on information of one and two carbon aliphatics, DBCP may be oxidized in the troposphere by hydroxyl radicals and hydrolyzed in an aqueous environment. Biodegradation of 1,2-dichloropropane does occur by soil microorganisms. However, the amount and speed of biodegradation and chemical degradation of DBCP is unknown.

Health Effects

DBCP has been found to be carcinogenic in two animal bioassays and mutagenic in the Ames assay system. In a gavage study, DBCP was found to produce significantly increased incidences of squamous-cell carcinomas of the forestomach of mice and rats and of mammary adenocarcinomas in female rats. In an inhalation study, rats had increased incidences of nasal cavity tumors and tumors of the tongue, while mice had increased incidences of nasal cavity tumors and lung tumors.

Men occupationally exposed to DBCP during its manufacture were found to have abnormally low sperm counts. Male rats exposed to DBCP during subchronic toxicity studies were also found to have abnormally low sperm cells as well as degenerative changes in the seminiferous tubules, decreased weight of the testes, and an increased proportion of abnormal sperm cells. Liver and kidney effects have also been noted in animal studies. Effects range from dilatation of the sinusoids and centrilobular congestion to cirrhosis and necrosis in the liver. Cloudy swelling of the epithelium of the proximal convoluted tubules and increased amounts of interstitial tissue have been found in the kidneys. Effects on blood cells were also noted in several studies. These effects include severe leukopenias and anemias in exposed monkeys and decreased activity of phagocytic cells in exposed rats.

Regulations and Standards

NIOSH Recommended Standard: 10 ppb (0.1 mg/m^3)

OSHA Standard (air): 1 ppb (9.6 ug/m^3) TWA

1,1-DICHLOROETHANE

Summary

1,1-Dichloroethane is quite volatile and probably is not very persistent in aquatic environments. Inhalation exposure to high doses causes central nervous system depression in humans and may cause hepatotoxicity. In animals, high doses cause liver and kidney damage and retard fetal development.

CAS Number: 75-34-3

Chemical Formula: CH_3CHCl_2

IUPAC Name: 1,1-Dichloroethane

Important Synonyms and Trade names: Ethylidene chloride, ethylidene dichloride

Chemical and Physical Properties

Molecular Weight: 98.96

Boiling Point: 57.3°C

Melting Point: -97.0°C

Specific Gravity: 1.1776 at 20°C

Solubility in Water: 5 g/liter

Solubility in Organics: Miscible in alcohol

Log Octanol/Water Partition Coefficient: 1.79

Vapor Pressure: 180 mm Hg at 20°C

Transport and Fate

1,1-Dichloroethane disperses from surface water primarily by volatilization into the troposphere, where it is subsequently broken down by hydroxylation. No studies on adsorption were found in the literature reviewed, but because of its water solubility and relatively low log octanol/water partition coefficient, 1,1-dichloroethane potentially could move through soil and enter the groundwater.

Health Effects

Limited toxicological testing of 1,1-dichloroethane has been conducted, although the literature indicates that 1,1-dichloroethane is one of the least toxic of the chlorinated ethanes. An NCI bioassay on 1,1-dichloroethane was limited by poor survival of test animals, but some marginal tumorigenic effects were seen. Inhalation exposure to high doses of 1,1-dichloroethane (over 16,000 mg/m^3) caused retarded fetal development in rats. 1,1-Dichloroethane was not found to be mutagenic using the Ames assay. 1,1-Dichloroethane causes central nervous system depression when inhaled at high concentrations, and evidence suggests that the compound is hepatotoxic in humans. Kidney and liver damage was seen in animals exposed to high levels of 1,1-dichloroethane. The oral LD_{50} value in the rat is 725 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

The available data were inadequate for establishing criteria.

OSHA Standard (air): 400 mg/m^3 TWA

ACGIH Threshold Limit Value: 810 mg/m^3 TWA - 200 ppm

1,2-DICHLOROETHANE

Summary

1,2-Dichloroethane (ethylene dichloride) is a volatile organic solvent, and volatilization and percolation into groundwater may be significant routes of transport. It has a low solubility in water and may be a component in nonaqueous-phase liquids. 1,2-Dichloroethane is carcinogenic in animals and mutagenic in bacterial test systems; it is a suspected human carcinogen.

CAS Number: 107-06-02

Chemical Formula: CH_2ClCH_2Cl

IUPAC Name: 1,2-Dichloroethane

Important Synonyms and Trade Names: Ethylene dichloride, glycol dichloride.

Chemical and Physical Properties

Molecular Weight: 98.96

Boiling Point: 83-84°C

Melting Point: -35.4°C

Specific Gravity: 1.253 at 20°C

Solubility in Water: 8 g/liter

Solubility in Organics: Miscible with alcohol, chloroform, and ether

Log Octanol/Water Partition Coefficient: 1.48

Vapor Pressure: 61 mm Hg at 20°C

Flash Point: 15°C (closed cup)

Transport and Fate

The primary method of dispersion from surface water for 1,2-dichloroethane is volatilization. In the atmosphere, 1,2-dichloroethane is rapidly broken down by hydroxylation, although some may be absorbed by atmospheric water and return to the earth by precipitation. No studies on the adsorption of 1,2-dichloroethane onto soil were reported in the literature examined. However, 1,2-dichloroethane has a low octanol/water partition coefficient, is slightly soluble in water, and therefore leaching through the soil into the groundwater is an expected route of dispersal.

Health Effects

1,2-Dichloroethane is carcinogenic in rats and mice, producing a variety of tumors. When administered by gavage, it produced carcinomas of the forestomach and hemangiosarcomas of the circulatory system in male rats; adenocarcinomas of the mammary gland in female rats; lung adenomas in male mice; and lung adenomas, mammary adenocarcinomas, and endometrial tumors in female mice. It is mutagenic when tested using bacterial test systems. Human exposure by inhalation to 1,2-dichloroethane has been shown to cause headache, dizziness, nausea, and liver and kidney dysfunction. Dermatitis may be produced by skin contact. In severe cases, leukocytosis (an excess of white blood cells) may be diagnosed; and internal hemorrhaging and pulmonary edema leading to death may occur. Similar effects are produced in experimental animals.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to be toxic in aquatic organisms.

Freshwater

Acute toxicity: 118 mg/liter
Chronic toxicity: 20 mg/liter

Saltwater

Acute toxicity: 113 mg/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of 1,2-dichloroethane in water are:

Risk	Concentration
10^{-5}	9.4 ug/liter
10^{-6}	0.94 ug/liter
10^{-7}	0.094 ug/liter

CAG Unit Risk (U.S. EPA): 9.1×10^{-2} $(mg/kg/day)^{-1}$

OSHA Standard (air): 200 mg/m^3 TWA
400 mg/m^3 Ceiling Level
800 mg/m^3 for 5 min every 3 hr, Peak Concentration

ACGIH Threshold Limit Value: 40 mg/m^3 TWA
10 ppm TWA

1,1-DICHLOROETHYLENE

Summary

1,1-Dichloroethylene (VDC, vinylidene chloride) caused kidney tumors (in males only) and leukemia in one study of mice exposed by inhalation, but the results of other studies were equivocal or negative. 1,1-Dichloroethylene is mutagenic, and it caused adverse reproductive effects when administered to rats and rabbits by inhalation. Chronic exposure causes liver damage, and acute exposure to high doses produces nervous system damage.

CAS Number: 75-35-4

Chemical Formula: CH_2CCl_2

IUPAC Name: 1,1-Dichloroethene

Important Synonyms and Trade Names: Vinylidene chloride, VDC, 1,1-dichloroethene, 1,1-DCE

Chemical and Physical Properties

Atomic Weight: 96.94

Boiling Point: 37°C

Melting Point: -122.1°C

Specific Gravity: 1.218 at 20°C

Solubility in Water: 400 mg/liter at 20°C

Solubility in Organics: Sparingly soluble in alcohol, ether, acetone, benzene, and chloroform

Log Octanol/Water Partition Coefficient: 1.48

Vapor Pressure: 500 mm Hg at 20°C

Vapor Density: 3.25

Transport and Fate

Volatilization appears to be the primary transport process for 1,1-dichloroethylene (VDC), and its subsequent photooxidation in the atmosphere by reaction with hydroxyl radicals is apparently the predominant fate process. Information on other transport and fate mechanisms was generally lacking for 1,1-dichloroethylene. However, by inference from related compounds, hydrolysis, sorption, bioaccumulation, biotransformation, and biodegradation probably all occur but at rates too slow to be of much significance.

Health Effects

1,1-Dichloroethylene caused kidney tumors in males and leukemia in males and females in one study of mice exposed by inhalation, gave equivocal results in other inhalation studies, and gave negative results in rats and mice following oral exposure and in hamsters following inhalation exposure. VDC was mutagenic in several bacterial assays. 1,1-Dichloroethylene did not appear to be teratogenic but did cause embryotoxicity and fetotoxicity when administered to rats and rabbits by inhalation. Chronic exposure to oral doses of VDC as low as 5 mg/kg/day caused liver changes in rats. Acute exposure to high doses causes central nervous system depression, but neurotoxicity has not been associated with low-level chronic exposure. The oral LD_{50} value for the rat is 1,500 mg/kg, and for the mouse it is 200 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are inadequate for establishing criteria. However, EPA did report the lowest values known to cause toxicity in aquatic organisms.

Freshwater

Acute toxicity: 11,600 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 224,000 ug/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of 1,2-dichloroethane in water are:

Risk	Concentration
10^{-5}	0.33 ug/liter
10^{-6}	0.033 ug/liter
10^{-7}	0.0033 ug/liter

CAG Unit Risk (U.S. EPA): 1.16 $(mg/kg/day)^{-1}$

ACGIH Threshold Limit Value: 5 ppm TWA
20 mg/m^3 TWA
485 mg/m^3 STEL

1,2-TRANS-DICHLOROETHYLENE

Summary

Chronic inhalation exposure to 1,2-trans-dichloroethylene (1,2-trans-DCE) causes liver degeneration, and acute exposure to high levels has adverse effects on the central nervous system.

CAS Number: 540-59-0

Chemical Formula: $C_2H_2Cl_2$

IUPAC Name: 1,2-trans-Dichloroethene

Important Synonyms and Trade Names: trans-Acetylene dichloride, dioform

Chemical and Physical Properties

Molecular Weight: 96.94

Boiling Point: 47.5°C

Melting Point: -50°C

Specific Gravity: 1.2565 at 20°C

Solubility in Water: 600 mg/liter

Solubility in Organics: Miscible with alcohol, ether, and acetone; very soluble in benzene and chloroform

Log Octanol/Water Partition Coefficient: 1.48 (calculated)

Vapor Pressure: 200 mm Hg at 14°C

Flash Point: 3°C (undefined isomers)

Transport and Fate

Due to the relatively high vapor pressure of 1,2-trans-dichloroethylene (1,2-trans-DCE), volatilization from aquatic systems to the atmosphere is quite rapid and appears to be the primary transport process. Aerial transport of this compound can occur and is partly responsible for its relatively wide environmental distribution. Although little applicable information is available, adsorption is probably an insignificant environmental fate process for 1,2-trans-DCE. The relatively low log octanol/water partition coefficient of 1,2-trans-DCE suggests that bioaccumulation

also is a relatively insignificant process. Although no information pertaining specifically to biodegradation of 1,2-trans-DCE is available, results with similar compounds suggest that this process probably occurs but at a very slow rate.

Photooxidation in the troposphere appears to be the dominant environmental fate of 1,2-trans-DCE. Once in the troposphere, the compound is attacked at the double bond by hydroxyl radicals, resulting in the formation of formic acid, hydrochloric acid, carbon monoxide, and formaldehyde. The half-life of 1,2-trans-DCE in the troposphere is estimated to be less than one day. Given the properties of similar compounds, photolysis of 1,2-trans-DCE in aquatic systems and photodissociation in the terrestrial environment are probably insignificant.

Health Effects

Very little information concerning exposure only to 1,2-trans-DCE is available. There are no reports of carcinogenic or teratogenic activity by 1,2-trans-DCE in animals or humans. It is reportedly nonmutagenic in a variety of test systems. Like other members of the chlorinated ethylene series, 1,2-trans-DCE has anesthetic properties. Exposure to high vapor concentrations has been found to cause nausea, vomiting, weakness, tremor, and cramps in humans. Repeated exposure via inhalation of 800 mg/m^3 (8 hours/day, 5 days/week, for 16 weeks) was reported to produce fatty degeneration of the liver in rats. The intraperitoneal injection LD_{50} value for the rat is 7,536 mg/kg.

Although nephrotoxic and cardiac sensitizing effects are associated with exposure to 1,1-dichloroethylene, the 1,2-DCE isomers have not been investigated with respect to this type of effects. 1,2-trans-Dichloroethylene can inhibit aminopyrine demethylation in rat liver microsomes in vitro, and it may thus interact with the hepatic drug-metabolizing monooxygenase system.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

The available data are not adequate for establishing criteria.

OSHA Standard: 790 mg/m^3 TWA

ACGIH Threshold Limit Value: 790 mg/m^3 TWA
1,000 mg/m^3 STEL.

ENDRIN

Summary

Endrin is a cyclodiene insecticide that is an isomer of dieldrin. It is probably retained in soils and sediments and is persistent in the environment. It is strongly bioaccumulated by aquatic organisms. Endrin is highly toxic to mammals, aquatic organisms, and terrestrial wildlife4 after acute exposure. It has not been shown to be carcinogenic or mutagenic, but it is a potent teratogen and reproductive toxin.

CAS Number: 72-20-8

Chemical Formula: $C_{12}H_8Cl_6O$

IUPAC Name: 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a octahydro-endo-1,4:5,8-dimethanonaphthalene

Important Synonyms and Trade Names: Endrex, hexadrin, mendrin

Chemical and Physical Properties

Molecular Weight: 380.9

Melting Point: Decomposes at 235°C

Specific Gravity: 1.65 at 25°C

Solubility in Water: 250 ug/liter at 25°C

Solubility in Organics: Soluble in acetone, benzene, carbon tetrachloride, hexane, and xylene

Log Octanol/Water Partition Coefficient: 5.6

Vapor Pressure: 2.7×10^{-7} mm Hg at 25°C

Transport and Fate

Endrin is quite persistent in the environment. Volatilization from soil surfaces and probably from surface water is an important transport process. Subsequent photolysis to delta-keto endrin and endrin aldehyde are apparently important fate processes. No information on the ability of endrin to adsorb to soils and sediments was found in the literature reviewed, but the physical properties of the chemical suggest that sorption would be an important fate process. Endrin is readily bioconcentrated by aquatic organisms, with concentration factors of 10^3 to 10^4. Biotransformation and biodegradation may also be important fate processes for endrin.

Health Effects

Endrin has not been shown to be carcinogenic or mutagenic. However, it is a potent reproductive toxin and teratogen in experimental animals. Reproductive effects included fetal mortality and growth retardation, while teratogenic effects included cleft palate, open eye, clubbed foot, meningoencephales, and fused ribs. Chronic exposure to low levels of endrin primarily results in nervous system damage but also has adverse effects on the heart, lungs, liver, and kidneys. The acute toxicity of endrin is due to its effects on the central nervous system. The acute oral and dermal LD_{50} values for endrin to the rat were both approximately 15 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

Freshwater

Acute toxicity: 0.18 ug/liter
Chronic toxicity: 0.0023 ug/liter

Saltwater

Acute toxicity: 0.037 ug/liter
Chronic toxicity: 0.0023 ug/liter

Human Health

Criterion: 1.0 ug/liter

Primary Drinking Water Standard: 1.0 ug/liter

OSHA Standard: 100 ug/m^3 TWA

ETHYLBENZENE

Summary

There is some evidence suggesting that ethylbenzene causes adverse reproductive effects in animals. Oral and inhalation exposure caused minor liver and kidney changes in rats. Ethylbenzene is a skin and eye irritant.

CAS Number: 100-41-4

Chemical Formula: $C_6H_5C_2H_5$

IUPAC Name: Ethylbenzene

Important Synonyms and Trade Names: Phenylethane, EB, ethylbenzol

Chemical and Physical Properties

Molecular Weight: 106.2

Boiling Point: 136.2°C

Melting Point: -95°C

Specific Gravity: 0.867 at 20°C (liquid)

Solubility in Water: 161 mg/liter at 25°C

Solubility in Organics: Freely soluble in organic solvents

Log Octanol/Water Partition Coefficient: 3.15

Vapor Pressure: 7 mm Hg at 20°C

Vapor Density: 3.66

Henry's Law constant: 6.44 atm. m^3/mole

Flash Point: 17.2°C

Transport and Fate

Only limited data are available on the transport and fate of ethylbenzene. Volatilization is probably the major route of elimination from surface water. Subsequent atmospheric reactions, especially photooxidation, are responsible for its fate. However, its high log octanol/water partition coefficient suggests that a

significant amount of ethylbenzene may be adsorbed by organic material in the sediment. Some soil bacteria are capable of using ethylbenzene as a source of carbon. However, the relative importance of this potential route of ethylbenzene elimination has not been determined.

Health Effects

Ethylbenzene has been selected by the National Toxicology Program to be tested for possible carcinogenicity, although negative results were obtained in mutagenicity assays in Salmonella typhimurium and Saccharomyces cerevisiae. There is recent animal evidence that ethylbenzene causes adverse reproductive effects. Ethylbenzene is a skin irritant, and its vapor is irritating to the eyes at a concentration of 200 ppm (870 mg/m^3) and above. When experimental animals were exposed to ethylbenzene by inhalation, 7 hours/day for 6 months, adverse effects were produced at concentrations of 600 ppm (2,610 mg/m^3) and above, but not at 400 ppm (1,740 mg/m^3). At 600 ppm rats and guinea pigs showed slight changes in liver and kidney weights, monkeys had slight changes in liver weight, and monkeys and rabbits experienced histopathologic changes in the testes. Similar effects on the liver and kidney were observed in rats fed ethylbenzene at 408 and 680 mg/kg/day for 6 months.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to have toxic effects in aquatic organisms.

Freshwater

Acute toxicity: 32,000 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 430 ug/liter
Chronic toxicity: No available data

Human Health

Criterion: 1.4 mg/liter

OSHA Standard (skin): 435 mg/m^3 TWA

ACGIH Threshold Limit Values: 435 mg/m^3 TWA
100 ppm TWA
545 mg/m^3 STEL
125 ppm STEL

LEAD

Summary

Lead is a heavy metal that exists in one of three oxidation states, 0, +2, and +4. There is suggestive evidence that some lead salts are carcinogenic, inducing kidney tumors in mice and rats. Lead is also a reproductive hazard, and it can adversely affect the brain and central nervous system by causing encephalopathy and peripheral neuropathy. Chronic exposure to low levels of lead can cause subtle learning disabilities in children. Exposure to lead can also cause kidney damage and anemia, and it may have adverse effects on the immune system.

CAS Number: 7439-92-1

Chemical Formula: Pb

IUPAC Name: Lead

Chemical and Physical Properties

Atomic Weight: 207.19

Boiling Point: 1,740°C

Melting Point: 327.502°C

Specific Gravity: 11.35 at 20°C

Solubility in Water: Insoluble; some organic compounds are soluble

Solubility in Organics: Soluble in HNO_3 and hot, concentrated H_2SO_4

Transport and Fate

Some industrially produced lead compounds are readily soluble in water. However, metallic lead and the common lead minerals are insoluble in water. Natural compounds of lead are not usually mobile in normal surface or groundwater because the lead leached from ores is adsorbed by ferric hydroxide or combines with carbonate or sulfate ions to form insoluble compounds.

Movement of lead and its inorganic and organolead compounds as particulates in the atmosphere is a major environmental transport process. Lead carried in the atmosphere can be removed by either wet or dry deposition. Although little evidence is available concerning the photolysis of lead compounds in natural waters, photolysis

in the atmosphere occurs readily. These atmospheric processes are important in determining the form of lead entering aquatic and terrestrial systems.

The transport of lead in the aquatic environment is influenced by the speciation of the ion. Lead exists mainly as the divalent cation in most unpolluted waters and becomes adsorbed into particulate phases. However, in polluted waters organic complexation is most important. Volatilization of lead compounds probably is not important in most aquatic environments.

Sorption processes appear to exert a dominant effect on the distribution of lead in the environment. Adsorption to inorganic solids, organic materials, and hydrous iron and manganese oxides usually controls the mobility of lead and results in a strong partitioning of lead to the bed sediments in aquatic systems. The sorption mechanism most important in a particular system varies with geological setting, pH, Eh, availability of ligands, dissolved and particulate ion concentrations, salinity, and chemical composition. The equilibrium solubility of lead with carbonate, sulfate, and sulfide is low. Over most of the normal pH range, lead carbonate, and lead sulfate control solubility of lead in aerobic conditions, and lead sulfide and the metal control solubility in anaerobic conditions. Lead is strongly complexed to organic materials present in aquatic systems and soil. Lead in soil is not easily taken up by plants, and therefore its availability to terrestrial organisms is somewhat limited.

Bioaccumulation of lead has been demonstrated for a variety of organisms, and bioconcentration factors are within the range of 100-1,000. Microcosm studies indicate that lead is not biomagnified through the food chain. Biomethylation of lead by microorganisms can remobilize lead to the environment. The ultimate sink of lead is probably the deep oceans.

Health Effects

There is evidence that several lead salts are carcinogenic in mice or rats, causing tumors of the kidneys after either oral or parenteral administration. Data concerning the carcinogenicity of lead in humans are inconclusive. The available data are not sufficient to evaluate the carcinogenicity of organic lead compounds or metallic lead. There is equivocal evidence that exposure to lead causes genotoxicity in humans and animals. The available evidence indicates that lead presents a hazard to reproduction and exerts a toxic effect on conception, pregnancy, and the fetus in humans and experimental animals.

Many lead compounds are sufficiently soluble in body fluids to be toxic. Exposure of humans or experimental animals to lead can result in toxic effects in the brain and central nervous system, the peripheral nervous system, the kidneys, and the hematopoietic system. Chronic exposure to inorganic lead by ingestion or inhalation can cause lead encephalopathy, and severe cases can result in permanent brain damage. Lead poisoning may cause peripheral neuropathy in adults and children, and permanent learning disabilities that are clinically undetectable in children may be caused by exposure to relatively low levels. Short-term exposure to lead can cause reversible kidney damage, but prolonged exposure at high concentrations may result in progressive kidney damage and possibly kidney failure. Anemia, due to inhibition of hemoglobin synthesis and a reduction in the life span of circulating red blood

cells, is an early manifestation of lead poisoning. Several studies with experimental animals suggest that lead may interfere with various aspects of the immune response.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life (Proposed Criteria)

The concentrations below are for active lead, which is defined as the lead that passes through a 0.45-um membrane filter after the sample is acidified to pH 4 with nitric acid.

Freshwater

Acute toxicity: $e^{\{1.34[\ln(\text{hardness})] - 2.014\}}$ ug/liter

Chronic toxicity: $e^{\{1.34[\ln(\text{hardness})] - 5.245\}}$ ug/liter

Saltwater

Acute toxicity: 220 ug/liter
Chronic toxicity: 8.6 ug/liter

Human Health

Criterion: 50 ug/liter

Primary Drinking Water Standard: 50 ug/liter

NIOSH Recommended Standard: 0.10 mg/m^3 TWA (inorganic lead)

OSHA Standard: 50 ug/m^3 TWA

ACGIH Threshold Limit Values:

0.15 mg/m^3 TWA (inorganic dusts and fumes)
0.45 mg/m^3 STEL (inorganic dusts and fumes)

MERCURY

Summary

Both organic and inorganic forms of mercury are reported to be teratogenic and embryotoxic in experimental animals. In humans, prenatal exposure to methylmercury has been associated with brain damage. Other major target organs for organic mercury compounds in humans are the central and peripheral nervous system and the kidney. In animals, toxic effects also occur in the liver, heart, gonads, pancreas, and gastrointestinal tract. Inorganic mercury is generally less acutely toxic than organic mercury compounds, but it does affect the central nervous system adversely.

Background Information

Several forms of mercury, including insoluble elemental mercury, inorganic species, and organic species, can exist in the environment. In general, the mercurous (+1) salts are such less soluble than the more commonly found mercuric (+2) slats. Mercury also forms many stable organic complexes that are generally much more soluble in organic liquids than in water. The nature and solubility of the chemical species that occur in an environmental system depend on the redox potential and the pH of the environment.

CAS Number: 7439-97-6

Chemical Formula: Hg

IUPAC Name: Mercury

Chemical and Physical Properties

Atomic Weight: 200.59

Boiling Point: 356.58°C

Melting Point: -38.87°C

Specific Gravity: 13.5939 at 20°C

Solubility in Water: 81.3 ug/liter at 30°C; some salts and organic compounds are soluble.

Solubility in Organics: Depends on chemical species

Vapor Pressure: 0.0012 mm Hg at 20°C

Transport and Fate

Mercury and certain of its compounds, including several inorganic species and dimethyl mercury, can volatilize to the atmosphere from aquatic and terrestrial sources. Volatilization is reduced by conversion of metallic mercury to complexed species and by deposition of HgS in reducing sediments, but even so atmospheric transport is the major environmental distribution pathway for mercury. Precipitation is the primary mechanism for removal of mercury from the atmosphere. Photolysis is important in the breakdown of airborne mercurials and may be important in some aquatic systems. Adsorption onto suspended and bed sediments is probably the most important process determinating the fate of mercury in the aquatic environment. Sorption is strongest into organic materials. Mercury in soils is generally complexed to organic compounds.

Virtually any mercury compound can be remobilized in aquatic systems by microbial conversion to methyl and dimethyl forms. Conditions reported to enhance biomethylation include large amounts of available mercury, large numbers of bacteria, the absence of strong complexing agents, near neutral pH, high temperatures, and moderately aerobic environments. Mercury is strongly bioaccumulated by numerous mechanisms. Methylmercury is the most readily accumulated and retained form of mercury in aquatic biota, and once it enters a biological system it is very difficult to eliminate.

Health Effects

When administered by intraperitoneal injection, metallic mercury produces implantation site sarcomas in rats. No other studies were found connecting mercury exposure with carcinogenic effects in animals or humans. Several mercury compounds exhibit a variety of genotoxic effects in eukaryotes. In general, organic mercury compounds are more toxic than inorganic compounds. Although brain damage due to prenatal exposure to methylmercury has occurred in human populations, no conclusive evidence is available to suggest that mercury causes anatomical defects in humans. Embryotoxicity and teratogenicity of methylmercury has been reported for a variety of experimental animals. Mercuric chloride is reported to be teratogenic in experimental animals. No conclusive results concerning the teratogenic effects of mercury vapor are available.

In humans, alkyl mercury compounds pass through the blood brain barrier and the placenta very rapidly, in contrast to inorganic mercury compounds. Major target organs are the central and peripheral nervous systems, and the kidney. Methylmercury is particularly hazardous because of the difficulty of eliminating it from the body. In experimental animals, organic mercury compounds can produce toxic effects in the gastrointestinal tract, pancreas, liver, heart, and gonads, with involvement of the endocrine, immunocompetent, and central nervous systems.

Elemental mercury is not highly toxic as an acute poison. However, inhalation of high concentrations of mercury vapor can cause pneumonitis, bronchitis, chest pains, dyspnea, coughing, stomatitis, gingivitis, salivation, and diarrhea. Soluble mercuric salts are highly poisonous on ingestion, with oral LD_{50} values of 20 to 60 mg/kg

reported. Mercurous compounds are less toxic when administered orally. Acute exposure to mercury compounds at high concentrations causes a variety of gastrointestinal symptoms and severe anuria with uremia. Signs and symptoms associated with chronic exposure involve the central nervous system and include behavioral and neurological disturbances.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life (Proposed Criteria)

Freshwater

Acute toxicity: 1.1 ug/liter
Chronic toxicity: 0.20 ug/liter

Saltwater

Acute toxicity: 1.9 ug/liter
Chronic toxicity: 0.10 ug/liter

Human Health

Criterion: 144 ng/liter

Primary Drinking Water Standard: 0.002 mg/liter

NIOSH Recommended Standard: 0.05 mg/m^3) TWA (inorganic mercury)

OSHA Standard: 0.1 mg/m^3) Ceiling Level

ACGIH Threshold Limit Values:

0.01 mg/m^3 TWA (alkyl compounds)
0.03 mg/m^3 STEL (alkyl compounds)
0.05 mg/m^3 TWA (vapor)
0.1 mg/m^3 TWA (aryl and inorganic compounds)

METHYLENE CHLORIDE

Summary

Methylene chloride increased the incidence of lung and liver tumors and sarcomas in rats and mice. It was found to be mutagenic in bacterial test systems. In humans, methylene chloride irritates the eyes, mucous membranes, and skin. Exposure to high levels adversely affects the central and peripheral nervous systems and the heart. In experimental animals, methylene chloride is reported to cause kidney and liver damage, convulsions, and paresis.

CAS Number: 75-09-2

Chemical Formula: CH_2Cl_2

IUPAC Name: Dichloromethane

Important Synonyms and Trade names: Methylene dichloride, methane dichloride

Chemical and Physical Properties

Molecular Weight: 84.93

Boiling Point: 40°C

Melting Point: -95.1°C

Specific Gravity: 1.3266 at 20°C

Solubility in Water: 13,200-20,000 mg/liter at 25°C

Solubility in Organics: Miscible with alcohol and ether

Log Octanol/Water Partition Coefficient: 1.25

Vapor Pressure: 362.4 mm Hg at 20°C

Vapor Density: 2.93

Transport and Fate

Volatilization to the atmosphere appears to be the major mechanism for removal of methylene chloride from aquatic systems and its primary environmental transport process. Photooxidation in the troposphere appears to be the dominant environmental fate of methylene chloride Once in the troposphere, the compound is attacked by

hydroxyl radicals, resulting in the formation of carbon dioxide, and to a lesser extent, carbon monoxide and phosgene. Phosgene is readily hydrolyzed to HCl and CO_2. About one percent of tropospheric methylene chloride would be expected to reach the stratosphere where it would probably undergo photodissociation resulting from interaction with high energy ultraviolet radiation. Aerial transport of methylene chloride is partly responsible for its relatively wide environmental distribution. Atmospheric methylene chloride may be returned to the earth in precipitation.

Photolysis, oxidation, and hydrolysis do not appear to be significant environmental fate processes for methylene chloride, and there is no evidence to suggest that either adsorption or bioaccumulation are important fate processes for this chemical. Although methylene chloride is potentially biodegradable, especially by acclimatized microorganisms, biodegradation probably only occurs at a very slow rate.

Health Effects

Methylene chloride is currently under review by the National Toxicology Program. Preliminary results indicate that it produced an increased incidence of lung and liver tumors in mice and mammary tumors in female and male rats. In a chronic inhalation study, male rats exhibited an increased incidence of sarcomas in the ventral neck region. However, the authors suggested that the relevance and toxicological significance of this finding were uncertain in light of available toxicity data. Methylene chloride is reported to be mutagenic in bacterial test systems. It also has produced positive results in the Fisher rat embryo cell transformation test. However, it has been suggested that the observed cell-transforming capability may have been due to impurities in the test material. There is no conclusive evidence that methylene chloride can produce teratogenic effects.

In humans, direct contact with methylene chloride produces eye, respiratory passage, and skin irritation. Mild poisoning due to inhalation exposure produce somnolence, lassitude, numbness and tingling of the limbs, anorexia, and lightheadedness, followed by rapid and complete recovery. More severe poisoning generally involve correspondingly greater disturbances of the central and peripheral nervous systems. Methylene chloride also has acute toxic effects on the heart, including the induction of arrhythmia. Fatalities reportedly due to methylene chloride exposure have been attributed to cardiac injury and heart failure. Methylene chloride is metabolized to carbon monoxide in vivo, and levels of carboxyhemoglobin in the blood are elevated after acute exposures. In experimental animals, methylene chloride is reported to cause kidney and liver damage, convulsions, and distal paresis. An oral LD_{50} value of 2,136 mg/kg, and an inhalation LC_{50} value of 88,000 mg/m^3/30 min are reported for the rat.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria.

Human Health

Criterion: 12.4 mg/liter (for protection against the noncarcinogenic effects of methylene chloride)

CAG Unit Risk (U.S. EPA): 1.4×10^{-2} $(mg/kg/day)^{-1}$

NIOSH Recommended Standards:

261 mg/m^3 TWA in the presence of no more than 9.9 mg/m^3 of CO
1,737 mg/m^3/15 min Peak Concentration

OSHA Standard: 1,737 mg/m^3 TWA
3,474 mg/m^3 Ceiling Level
6,948 mg/m^3 Peak Concentration (5 min in any 3 hr)

ACGISH Threshold Limit Value: 350 mg/m^3 TWA
100 ppm TWA
1,740 mg/m^3 STEL
500 ppm STEL

TETRACHLOROETHYLENE

Summary

Tetrachloroethylene (PCE, perchloroethylene) induced liver tumors when administered orally to mice and was found to be mutagenic using a microbial assay system. Reproduction toxicity was observed in pregnant rats and mice exposed to high concentrations. Animals exposed by inhalation to tetrachloroethylene exhibited liver, kidney, and central nervous system damage.

CAS Number: 127-18-4

Chemical Formula: C_2Cl_4

IUPAC Name: Tetrachloroethene

Important Synonyms and Trade Names: Perchloroethylene, PCE

Chemical and Physical Properties

Molecular Weight: 165.83

Boiling Point: 121°C

Melting Point: -22.7°C

Specific Gravity: 1.63

Solubility in Water: 150 to 200 mg/liter at 20°C

Solubility in Organics: Soluble in alcohol, ether, and benzene

Log Octanol/Water Partition Coefficient: 2.88

Vapor Pressure: 14 mm Hg at 20°C

Transport and Fate

Tetrachloroethylene (PCE) rapidly volatilizes into the atmosphere where it reacts with hydroxyl radicals to produce HCl, CO, CO_2, and carboxylic acid. This is probably the most important transport and fate process for tetrachloroethylene in the environment. PCE will leach into the groundwater, especially in soils of low organic content. In soils with high levels of organics, PCE adsorbs to these materials and can be bioaccumulated to some degree. However, it is unclear if tetrachloroethylene bound to organic material can be degraded by microorganisms or must be desorbed to be destroyed. There is some evidence that higher organisms can metabolize PCE.

Health Effects

Tetrachloroethylene was found to produce liver cancer in male and female mice when administered orally by gavage. Unpublished gavage studies in rats and mice performed by the National Toxicology Program (NTP) showed hepatocellular carcinomas in mice and a slight, statistically insignificant increase in a rare type of kidney tumor. NTP is also conducting an inhalation carcinogenicity study. Elevated mutagenic activity was found in Salmonella strains treated with tetrachloroethylene. Delayed ossification of skull bones and sternebrae were reported in offspring of pregnant mice exposed to 2,000 mg/m^3 of tetrachloroethylene for 7 hours/day on days 6-15 of gestation. Increased fetal resorptions were observed after exposure of rats to tetrachloroethylene. Renal toxicity and hepatotoxicity have been noted following chronic inhalation exposure of rats to tetrachloroethylene. Renal toxicity and hepatotoxicity have been noted following chronic inhalation exposure of rats to tetrachloroethylene levels of 1,356 mg/m^3. During the firs 2 weeks of a subchronic inhalation study, exposure to concentrations of 1,6222 ppm (10,867 mg/m^3) of tetrachloroethylene produced signs of central nervous system depression, and chlolinergic stimulation was observed among rabbits, monkeys, rats, and guinea pigs.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to be toxic in aquatic organisms.

Freshwater

Acute toxicity: 5,280 ug/liter
Chronic toxicity: 840 ug/liter

Saltwater

Acute toxicity: 10,200 ug/liter
Chronic toxicity: 450 ug/liter

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of tetrachloroethylene in water are:

Risk	Concentration
10^{-5}	8.0 ug/liter
10^{-6}	0.8 ug/liter
10^{-7}	0.08 ug/liter

CAG Unit Risk (U.S. EPA): 5.1×10^{-2} $(mg/kg/day)^{-1}$

NIOSH Recommended Standards (air):
335 mg/m^3 TWA
670 mg/m^3 15-min Ceiling Level

OSHA Standard (air):
670 mg/m^3 TWA
1,340 mg/m^3 Ceiling Level
2,010 mg/m^3 for 5 min every 3 hr, Peak Concentration

ACGIH Threshold Limit Value:
50 ppm TWA
335 mg/m^3 TWA
200 ppm STEL
1,340 mg/m^3 STEL

TOLUENE

Summary

Toluene has been shown to be embryotoxic in experimental animals, and the incidence of cleft palate increased in the offspring of dosed mice. Chronic inhalation exposure to high levels of toluene caused cerebellar degeneration and an irreversible encephalopathy in animals. In humans, acute exposure depressed the central nervous system and caused narcosis.

CAS Number: 108-88-3

Chemical Formula: $C_6H_5CH_3$

IUPAC Name: Methylbenzene

Important Synonyms and Trade Names: Toluol, phenylmethane

Chemical and Physical Properties

Molecular Weight: 92.13

Boiling Point: 110.6°C

Melting Point: -95°C

Specific Gravity: 0.8669 at 20°C

Solubility in Water: 534.8 mg/liter

Solubility in Organics: Soluble in acetone, ligroin, and carbon disulfide; miscible with alcohol, ether, benzene, chloroform, glacial acetic acid, and other organic solvents

Log Octanol/Water Partition Coefficient: 2.69

Vapor Pressure: 28.7 mm Hg at 25°C

Vapor Density: 3.14

Flash Point: 4.4°C

Transport and Fate

Volatilization appears to be the major route of removal of toluene from aquatic environments, and atmospheric reactions of toluene probably subordinate all other fate processes. Photooxidation is the primary atmospheric fate process for toluene, and benzaldehyde is reported to be the principal organic product. Subsequent precipitation or dry deposition can deposit toluene and its oxidation products into aquatic and terrestrial systems. Direct photolytic cleavage of toluene is energetically improbable in the troposphere, and oxidation and hydrolysis are probably not important as aquatic fates.

The log octanol/water partition coefficient of toluene indicates that sorption processes may be significant. However, no specific environmental sorption studies are available, and the extent to which adsorption by sedimentary and suspended organic material may interfere with volatilization is unknown. Bioaccumulation is probably not an important environmental fate process. Although toluene is known to be degraded by microorganisms and can be detoxified and excreted by mammals, the available data do not allow estimation of the relative importance of biodegradation/biotransformation processes. Almost all toluene discharged to the environment by industry is in the form of atmospheric emissions.

Health Effects

There is no conclusive evidence that toluene is carcinogenic or mutagenic in animals or humans. The National Toxicological Program is currently conducting an inhalation carcinogenicity bioassay in rats and mice.

Oral administration of toluene at doses as low as 260 mg/kg produced a significant increase in embryonic lethality in mice. Decreased fetal weight was observed at doses as low as 434 mg/kg, and an increased incidence of cleft palate was seen at doses as low as 867 mg/kg. However, other researches have reported that toluene is embryotoxic but not teratogenic in laboratory animals. There are no accounts of a teratogenic effect in humans after exposure to toluene.

Acute exposure to toluene at concentrations of 375-1,500 mg/kg produces central nervous system depression and narcosis in humans. However, even exposure to quantities sufficient to produce unconsciousness fail to produce residual organ damage. The rat oral LD_{50} value and inhalation LC_{LO} value are 5,000 mg/kg and 15,000 mg/m^3, respectively. Chronic inhalation exposure to toluene at relatively high concentrations produces cerebellar degeneration and an irreversible encephalopat in mammals.

Toluene in sufficient amounts appears to have the potential to alter significantly the metabolism and resulting bioactivity of certain chemicals. For example, coadministration of toluene along with benzene or styrene has been shown to suppress the metabolism of benzene or styrene in rats.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to cause toxicity in aquatic organisms.

Freshwater

Acute toxicity: 17,500 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 6,300 ug/liter
Chronic toxicity: 5,000 ug/liter

Human Health

Criterion: 14.3 mg/liter

NIOSH Recommended Standards: 375 mg/m^3 TWA
560 mg/m^3 STEL

OSHA Standards: 750 mg/m^3 TWA
1,120 mg/m^3 Ceiling Level

ACGIH Threshold Limit Value: 100 ppm TWA
375 mg/m^3 TWA
150 ppm STEL
560 mg/m^3 STEL

1,1,1-TRICHLOROETHANE

Summary

Preliminary results suggest that 1,1,1-trichloroethane (1,1,1-TCA) induces liver tumors in female mice. It was shown to be mutagenic using the Ames assay, and it causes transformation in cultured rat embryo cells. Inhalation exposure to high concentrations of 1,1,1-TCA depressed the central nervous system; affected cardiovascular function; and damaged the lungs, liver, and kidneys in animals and humans. Irritation of the skin and mucous membranes has also been associated with human exposure to 1,1,1-trichloroethane.

CAS Number: 71-55-6

Chemical Formula: CH_3CCl_3

IUPAC Name: 1,1,1-Trichloroethane

Important Synonyms and Trade Names: Methyl chloroform, chlorothene, 1,1,1-TCA

Chemical and Physical Properties

Molecular Weight: 133.4

Boiling Point: 74.1°C

Melting Point: -30.4°C

Specific Gravity: 1.34 at 20°C (liquid)

Solubility in Water: 480-4,400 mg/liter at 20°C (several divergent values were reported in the literature)

Solubility in Organics: Soluble in acetone, benzene, carbon tetrachloride, methanol, ether, alcohol, and chlorinated solvents

Log Octanol/Water Partition Coefficient: 2.17

Vapor Pressure: 123 mm Hg at 20°C

Vapor Density: 4.63

Transport and Fate

1,1,1-Trichloroethane (1,1,1-TCA) disperses from surface water primarily by volatilization. Several studies have indicated that 1,1,1-trichloroethane may be adsorbed onto organic materials in the sediment, but this is probably not an important route of elimination from surface water. 1,1,1-Trichloroethane can be transported in the groundwater, but the speed of transport depends on the composition of the soil.

Photooxidation by reaction with hydroxyl radicals in the atmosphere is probably the principal fate process for this chemical.

Health Effects

1,1,1-Trichloroethane was retested for carcinogenicity because in a previous study by NCI, early lethality precluded assessment of carcinogenicity. Preliminary results indicate that 1,1,1-TCA increased the incidence of combined hepatocellular carcinomas and adenomas in female mice when administered by gavage. There is evidence that 1,1,1-trichloroethane is mutagenic in Salmonella typhimurium and causes transformation in cultured rat embryo cells. These data suggest that the chemical may be carcinogenic.

Other effects of 1,1,1-TCA are seen only at concentrations well above those likely in an open environment. The most notable toxic effects of 1,1,1-trichloroethane in humans and animals are central nervous system depression, including anesthesia at very high concentrations and impairment of coordination, equilibrium, and judgment at lower concentrations (350 ppm and above); cardiovascular effects, including premature ventricular contractions, decreased blood pressure, and sensitization to epinephrine-induced arrhythmia; and adverse effects on the lungs, liver, and kidneys. Irritation of the skin and mucous membranes resulting from exposure to 1,1,1-trichloroethane has also been reported. The oral LD_{50} value of 1,1,1-trichloroethane in rats is about 11,000 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report, the lowest values of the two trichloroethanes (1,1,1 and 1,1,2) known to be toxic in aquatic organisms.

Freshwater

Acute toxicity: 18 mg/liter
Chronic toxicity: 8.4 mg/liter

Saltwater

Acute toxicity: 31.2 mg/liter
Chronic toxicity: No available data

Human Health

Criterion: 18.4 mg/liter

NIOSH Recommended Standard: 350 ppm (1,910 mg/m^3)/15 min Ceiling Level

OSHA Standard: 350 ppm (1,910 mg/m^3) TWA

ACGIH Threshold Limit Value: 350 ppm TWA
1,400 mg/m^3 TWA
450 ppm STEL
2,450 mg/m^3 STEL.

1,1,2-TRICHLOROETHANE

Summary

1,1,2-Trichloroethane induced liver tumors and pheochromocytomas in mice. It caused liver and kidney damage in dogs.

CAS Number: 79-00-5

Chemical Formula: $CH_2ClCHCl_2$

IUPAC Name: 1,1,2-Trichloroethane

Important Synonyms and Trade Names: Vinyl trichloride, ethane trichloride

Chemical and Physical Properties

Molecular Weight: 133.41

Boiling Point: 133.8°C

Melting Point: -36.5°C

Specific Gravity: 1.4397 at 25°C

Solubility in Water: 4,500 mg/liter at 20°C

Solubility in Organics: Soluble in alcohol, ether, and chloroform

Log Octanol/Water Partition Coefficient: 2.17

Vapor Pressure: 19 mm Hg at 20°C

Vapor Density: 4.63

Transport and Fate

Volatilization and subsequent photooxidation in the troposphere are probably the primary transport and fate processes for 1,1,2-trichloroethane. Some sorption, bioaccumulation, and biodegradation may occur, but these processes are probably not very important processes for trichloroethane transport or fate.

1,1,2-Trichloroethane induced heptacellular carcinomas and pheochromocytoma of the adrenal gland in male and female mice but did not produce a significant increase in tumor incidence in male or female rats. It was not mutagenic when tested using the Ames assay. No information was found concerning the reproductive toxicity or

eratogenicity of 1,1,2-trichloroethane. No chronic studies were found on the toxicity of 1,1,2-trichloroethane but single doses as low as 400 mg/kg caused liver and kidney damage in dogs. The oral LD_{50} value for 1,1,2-trichloroethane in rats is 835 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not sufficient for establishing criteria. However, EPA did report the lowest values known to be toxic in aquatic organisms.

Freshwater

Acute toxicity: 18,000 ug/liter
Chronic toxicity: 9,400 ug/liter

Saltwater

Acute toxicity: No available data
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of 1,1,2-trichloroethane in water are:

Risk	Concentration
10^{-5}	6.0 ug/liter
10^{-6}	0.6 ug/liter
10^{-7}	0.06 ug/liter

CAG Unit Risk (U.S. EPA): 5.7×10^{-2} $(mg/kg/day)^{-1}$

ACGIH Threshold Limit Value: 10 ppm TWA (skin)
45 mg/m^3 TWA (skin)

TRICHLOROETHYLENE

Summary

Trichloroethylene (TCE) induced hepatocellular carcinomas in mice and was mutagenic when tested using several microbial assay systems. Chronic inhalation exposure to high concentrations caused liver, kidney, and neural damage and dermatological reactions in animals.

CAS Number: 79-01-06

Chemical Formula: C_2HCl_3

IUPAC Name: Trichloroethene

Important Synonyms and Trade Names: Trichloroethene, TCE, and ethylene trichloride

Chemical and Physical Properties

Molecular Weight: 131.5

Boiling Point: 87°C

Melting Point: -73°C

Specific Gravity: 1.4642 at 20°C

Solubility in Water: 1,000 mg/liter

Solubility in Organics: Soluble in alcohol, ether, acetone, and chloroform

Log Octanol/Water Partition Coefficient: 2.29

Vapor Pressure: 60 mm Hg at 20°C

Vapor Density: 4.53

Transport and Fate

Trichloroethylene (TCE) rapidly volatilizes into the atmosphere where it reacts with hydroxyl radicals to produce hydrochloric acid, carbon monoxide, carbon dioxide, and carboxylic acid. This is probably the most important transport and fate process for trichloroethylene in surface water and in the upper layer of soil. TCE adsorbs to organic materials and can be bioaccumulated to some degree. However, it is unclear whether trichloroethylene bound to organic materiaL can be degraded by

microorganisms or must be desorbed to be destroyed. There is some evidence that higher organisms can metabolize TCE. Trichloroethylene leaches into the groundwater fairly readily, and it is a common contaminant of groundwater around hazardous waste sites.

Health Effects

Trichloroethylene is carcinogenic to mice after oral administration, producing hepatocellular carcinomas. It was found to be mutagenic using several microbial assay systems. Trichloroethylene does not appear to cause reproductive toxicity or teratogenicity. TCE has been shown to cause renal toxicity, hepatotoxicity, neurotoxicity, and dermatological reactions in animals following chronic exposure to levels greater than 2,000 mg/m^3 for 6 months. Trichloroethylene has low acute toxicity; the acute oral LD_{50} value in several species ranged from 6,000 to 7,000 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to have toxic effects in aquatic organisms.

Freshwater

Acute toxicity: 45 mg/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 2 mg/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of trichloroethylene in water are:

Risk	Concentration
10^{-5}	27 ug/liter
10^{-6}	2.7 ug/liter
10^{-7}	0.27 ug/liter

CAG Unit Risk (U.S. EPA): 1.1×10^{-2} $(mg/kg/day)^{-1}$

NIOSH Recommended Standards (air):
540 mg/m^3 TWA
760 mg/m^3 10-min Ceiling Level

OSHA Standard (skin): 540 mg/m^3 TWA
1,075 mg/m^3/15-min Ceiling Level
1,620 mg/m^3 for 5 min every 3 hr, Peak Concentration

ACGIH Threshold Limit Values: 50 ppm TWA
270 mg/m^3 TWA
200 ppm STEL
1,080 mg/m^3 STEL

XYLENES

Summary

Xylene has been shown to be fetotoxic in rats and mice. In humans, exposure to high concentrations of xylene adversely affects the central nervous system and irritates the mucous membranes.

Background Information

Xylene has three isomers, o-, m-, and p-xylene. These three generally have similar chemical and biological characteristics and therefore will be discussed together.

CAS Number:

Mixed:	1330-20-7
m-Xylene:	108-38-3
o-Xylene:	95-47-6
p-Xylene:	106-42-3

Chemical Formula: $C_6H_4(CH_3)_2$

IUPAC Name: Dimethylbenzene

Important Synonyms and Trade Names:

Mixed xylene:	Dimethylbenzene, xylol
m-Xylene:	1,3-Dimethylbenzene, m-xylol
o-Xylene:	1,2-Dimethylbenzene, o-xylol
p-Xylene:	1,4-Dimethylbenzene, p-xylol

Chemical and Physical Properties

Molecular Weight: 106.17

Boiling Point:

Mixed:	137-140°C
m-Xylene:	139°C
o-Xylene:	144°C
p-Xylene:	138°C

Melting Point:

m-Xylene:	-48°C
o-Xylene:	-25°C
p-Xylene:	13°C

Specific Gravity: 0.86

Solubility in Water: 160 mg/liter at 25°C

Solubility in Organics: Soluble in alcohol, ether, and other organic solvents.

Log Octanol/Water Partition Coefficient: 3

Vapor Pressure: 10 mm Hg at 25°C

Vapor Density: 3.7

Flash Point: 25°C (closed cup)

Transport and Fate

Volatilization and subsequent photooxidation by reaction with hydroxyl radicals in the atmosphere are probably important transport and fate processes for xylene in the upper layer of soil and in aquatic environments. Products of the hydroxylation reaction include carbon dioxide, peroxyacetylnitrate (PAN), and cresol. Xylene binds to sediment in water and to organics in soils and undergoes microbial degradation. Biodegradation is probably the most important fate process in both soils and the aquatic environment. Xylenes have been shown to persist for up to 6 months in soil. Because of their low water solubility and rapid biodegradation, xylenes are unlikely to leach into groundwater in high concentrations.

Health Effects

The National Toxicology Program (NTP) is testing xylene for carcinogenicity by administering it orally to rats and mice. Although the results have not been finalized, it does not appear to be carcinogenic in rats. Results have not been reported for mice. Xylene was not found to be mutagenic in a battery of short-term assays. Xylene is not teratogenic but has caused fetotoxicity in rats and mice. Acute exposure to rather high levels of xylene affects the central nervous system and irritates the mucous membranes. There is limited evidence of effects on other organ systems, but it was not possible to attribute these effects solely to xylene as other solvents were present. The oral LD_{50} value of xylene in rats is 5,000 mg/kg.

Regulations and Standards

NIOSH Recommended Standard (air):
435 mg/m^3 TWA
870 mg/m^3 10-min Ceiling Level

OSHA Standard: 435 mg/m^3 TWA

ACGIH Threshold Limit Values:
100 ppm TWA
435 mg/m^3 TWA
150 ppm STEL
655 mg/m^3 STEL

ZINC

Summary

Ingestion of excessive amounts of zinc can cause fever, vomiting, and stomach cramps. Zinc oxide fumes can cause metal fume fever. Inhalation of mists or fumes may irritate the respiratory tract, and contact with zinc chloride may irritate the eyes and skin. High levels of zinc in the diet have been shown to retard growth and produce defective mineralization of bone.

Background Information

Zinc generally exists in nature as a salt with a valence of +2, although it is also found in four other stable valences.

CAS Number: 7440-66-6

Chemical Formula: Zn

IUPAC Name: Zinc

Chemical and Physical Properties

Atomic Weight: 65.38

Boiling Point: 907°C

Melting Point: 419.58°C

Specific Gravity: 7.133 at 25°C

Solubility in Water: Insoluble; some salts are soluble

Solubility in Organics: Soluble in acid and alkali

Vapor Pressure: 1 mm Hg at 487°C

Transport and Fate

Zinc can occur in both suspended and dissolved forms. Dissolved zinc may occur as the free (hydrated) zinc ion or as dissolved complexes and compounds with varying degrees of stability and toxicity. Suspended (undissolved) zinc may be dissolved following minor changes in water chemistry or may be sorbed to suspended matter. The predominant fate of zinc in aerobic aquatic systems is sorption of the divalent cation by hydrous iron and manganese oxides, clay minerals, and organic material. The efficiency of these materials in removing zinc from solution varies according to their compositions and concentrations; the pH and salinity of the water; the

concentrations of complexing ligands; and the concentration of zinc. Concentrations of zinc in suspended and bed sediments always exceed concentrations in ambient water. In reducing environments, precipitation of zinc sulfide limits the mobility of zinc. However, under aerobic conditions, precipitation of zinc compounds is probably important only where zinc is present in high concentrations. Zinc tends to be more readily sorbed at higher pH than lower pH and tends to be desorbed from sediments as salinity increases. Compounds of zinc with the common ligands of surface waters are soluble in most neutral and acidic solutions, so that zinc is readily transported in most unpolluted, relatively organic-free waters.

The relative mobility of zinc in soil is determined by the same factors affecting its transport in aquatic systems. Atmospheric transport of zinc is also possible. However, except near sources such as smelters, zinc concentrations in air are relatively low and fairly constant.

Since it is an essential nutrient, zinc is strongly bioaccumulated even in the absence of abnormally high ambient concentrations. Zinc does not appear to be biomagnified. Although zinc is actively bioaccumulated in aquatic systems, the biota appear to represent a relatively minor sink compared to the sediments. Zinc is one of the most important metals in biological systems. Since it is actively bioaccumulated, the environmental concentrations of zinc probably exhibit seasonal fluctuations.

Health Effects

Testicular tumors have been produced in rats and chickens when zinc salts are injected intratesticularly, but not when other routes of administration are used. Zinc may be indirectly important with regard to cancer since its presence seems to be necessary for the growth of tumors. Laboratory studies suggest that although zinc-deficient animals may be more susceptible to chemical induction of cancer, tumor growth is slower in these animals. There is no evidence that zinc deficiency has any etiological role in human cancer. There are no data available to suggest that zinc is mutagenic or teratogenic in animals or humans.

Zinc is an essential trace element that is involved in enzyme functions, protein synthesis, and carbohydrate metabolism. Ingestion of excessive amounts of zinc may cause fever, vomiting, stomach craps, and diarrhea. Fumes of freshly formed zinc oxide can penetrate deep into the alveoli and cause metal fume fever. Zinc oxide dust does not produce this disorder. Contact with zinc chloride can cause skin and eye irritation. Inhalation of mists or fumes may irritate the respiratory and gastrointestinal tracts. Zinc in excess of 0.25% in the diet of rats causes growth retardation, hypochromic anemia, and defective mineralization of bone. No zinc toxicity is observed at dietary levels below 0.25%.

Studies with animals and humans indicate that metabolic changes may occur due to the interaction of zinc and other metals in the diet. Exposure to cadmium can cause changes in the distribution of zinc, with increases in the liver and kidneys, organs where cadmium also accumulates. Excessive intake of zinc may cause copper

deficiencies and result in anemia. Interaction of zinc with iron or lead may also lead to changes that are not produced when the metals are ingested individually.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

Freshwater

Acute toxicity: $e^{\{0.83[\ln(\text{hardness})] + 1.95\}}$ ug/liter
Chronic toxicity: 47 ug/liter

Saltwater

Acute toxicity: 170 ug/liter
Chronic toxicity: 58 ug/liter

Human Health

Organoleptic criterion: 5 mg/liter

Secondary Drinking Water Standard: 5 mg/liter

NIOSH Recommended Standard: 5 mg/m^3 (zinc oxide)

OSHA Standard: 5 mg/m^3 TWA (zinc oxide)

ACGIH Threshold Limit Values:

Zinc chloride fume:	1 mg/m^3 TWA
	2 mg/m^3 STEL
Zinc oxide fume:	5 mg/m^3 TWA
	10 mg/m^3 STEL
Zinc oxide dust:	10 mg/m^3 TWA (nuisance particulate)
Zinc stearate:	10 mg/m^3 TWA (nuisance particulate)
	20 mg/m^3 STEL

ATTACHMENT 2

EMPLOYEE EXPOSURE/INJURY INCIDENT REPORT
RMA EMERGENCY RESPONSE PROCEDURE

OCCUPATIONAL EXPOSURE GUIDE

OSHA No. 101
Case or File No. .....

Form approved
OMB No. 44R 1453

Supplementary Record of Occupational Injuries and Illnesses

EMPLOYER

1. Name .....
2. Mail address .....
   (No. and street) (City or town) (State)
3. Location, if different from mail address .....

INJURED OR ILL EMPLOYEE

4. Name ..... Social Security No. .....
   (First name) (Middle name) (Last name)
5. Home address .....
   (No. and street) (City or town) (State)
6. Age ..... 7. Sex: Male..... Female..... (Check one)
8. Occupation .....
   (Enter regular job title, *not* the specific activity he was performing at time of injury.)
9. Department .....
   (Enter name of department or division in which the injured person is regularly employed, even though he may have been temporarily working in another department at the time of injury.)

THE ACCIDENT OR EXPOSURE TO OCCUPATIONAL ILLNESS

10. Place of accident or exposure .....
    (No. and street) (City or town) (State)
    If accident or exposure occurred on employer's premises, give address of plant or establishment in which it occurred. Do not indicate department or division within the plant or establishment. If accident occurred outside employer's premises at an identifiable address, give that address. If it occurred on a public highway or at any other place which cannot be identified by number and street, please provide place references locating the place of injury as accurately as possible.
11. Was place of accident or exposure on employer's premises? ..... (Yes or No)
12. What was the employee doing when injured? .....
    (Be specific. If he was using tools or equipment or handling material, name them and tell what he was doing with them.)
13. How did the accident occur? .....
    (Describe fully the events which resulted in the injury or occupational illness. Tell what happened and how it happened. Name any objects or substances involved and tell how they were involved. Give full details on all factors which led or contributed to the accident. Use separate sheet for additional space.)

OCCUPATIONAL INJURY OR OCCUPATIONAL ILLNESS

14. Describe the injury or illness in detail and indicate the part of body affected. .....
    (e.g.: amputation of right index finger at second joint; fracture of ribs; lead poisoning; dermatitis of left hand, etc.)
15. Name the object or substance which directly injured the employee. (For example, the machine or thing he struck against or which struck him; the vapor or poison he inhaled or swallowed; the chemical or radiation which irritated his skin; or in cases of strains, hernias, etc., the thing he was lifting, pulling, etc.)
16. Date of injury or initial diagnosis of occupational illness .....
    (Date)
17. Did employee die? ..... (Yes or No)

OTHER

18. Name and address of physician .....
19. If hospitalized, name and address of hospital .....

Date of report ..... Prepared by .....
Official position .....

EMPLOYEE EXPOSURE/INJURY INCIDENT REPORT

(A separate report is to be completed for each incident and submitted immediately to the Director, Corporate Health and Safety for consideration.)

DATE:_____

1. Employee's Name:_____ 2. Employee No._____

3. Sex: M_____F_____4. Age:_____ 5. Marital Status:_____

6. Office/Department:_____ 7. WO No:_____

8. Title:_____

9. Incident:

   a. Type - Possible Exposure_____Exposure_____

      Physical Injury_____

   b. Location_____ _____

   c. Date of Incident_____d. Time of Incident_____

   e. Date of Reporting Incident_____

   f. Date of Initial Diagnosis_____

   g. Person to Whom Incident was Reported_____

   h. Weather Condition During Incident - Temperature_____

      Wind Speed & Direction_____Humidity_____

      Cloud Cover_____Clear_____Precipitation_____

   i. Name of Materials Potentially Encountered:

      Chemical (liquid, solid, gas, vapor, fume, mist):_____

      _____

      Radiological:_____

      _____

      Other:_____

      _____

j. Has the client been notified of the incident? Yes____No____
If "yes", attach documentation.

10. Nature of the Exposure/Injury:

a. State the nature of the exposure/injury in detail, list the parts of the body affected and how it occurred. (Attach extra sheets if needed.)

_____

_____

_____

b. Did you receive medical care? Yes_____No_____

c. If so, When?_____

d. Where? On-Site_____Off-Site_____

e. By Whom? Name of Paramedic_____

Name of Physician_____

Other_____

f. If "Off-Site", name facility (hospital, clinic, etc); obtain Copy of medical report._____

_____

g. Length of stay at the facility_____

h. Was the Director, Corporate Health and Safety contacted? ___

Yes_____No_____. If Yes, When?_____

i. Was the WESTON Medical/Toxicological System activated?

Yes_____No_____ If so, who was the contact_____

j. Did the exposure/injury result in death? Yes_____No_____

If so, give the date_____

k. Did the exposure/injury result in permanent disability?

Yes_____No_____. If so, explain:_____

_____

l. Has the employee returned to work? Yes_____No_____

If so, give date_____

m. List the names of other persons affected during this incident:

_____

_____

n. List the names of persons who witnessed the exposure/injury incident:

_____

_____

11. Possible cause of the exposure/injury:

a. What was the name and title of the field team leader or immediate supervisor at the site of the incident?

_____

b. Was the operation being conducted under an extablished Safety Plan? Yes_____No_____. If yes, attach a copy. If no, explain:

_____

c. Was protective equipment and clothing used by the employee?

Yes_____No_____. If yes, list items:_____

_____

_____

_____

d. Did any limitations in safety equipment or protective clothing contribute or affect exposure, or contribute to the injury? If so, explain:_____

_____

_____

_____

e. What was the employee doing when the exposure/injury occurred? (Describe briefly as "Site Reconnaissance", "Site Categorization", "Sampling", etc.)

_____

_____

f. Where exactly on-site or off-site did the exposure/injury occur?

_____

_____

g. How did the exposure/injury occur? (Describe fully what factors led up to and/or contributed to the incident.)

_____

_____

_____

_____

12. Attach any other relevant data and information regarding this incident.

13. Name of person(s) initiating report, job title, phone number:

_____

_____

_____ _____

(Employee Signature) (Date)

_____ _____

(Field Team Leader or Supervisor's Signature) (Date)

Medical Consultants Comments: _____

_____

_____

_____

_____

_____

_____

_____ _____

Physician's Signature Date

_____

_____

(For Director, Corporate Health and Safety use only)

Reviewed and Comments: _____

_____

_____

Action Required: Yes_____ No_____. If so, what action:_____

_____

_____

_____

Follow-up action carried out: _____

_____

Date

_____

Director, Corporate Health and Safety

Explain Corrective Actions to be Taken to Prevent Similar Reoccurances:

_____

_____

_____

_____

_____

_____

_____

_____

_____ _____

(Technical Assistance Team Leader's Signature) (Date)

_____ _____

(Employee's Signature) (Date)

1. ROCKY MOUNTAIN ARSENAL
STANDING OPERATING PROCEDURE FOR:

2. ITEM: EMERGENCY RESPONSE PLAN FOR FIELD ACTIVITY DISCOVERED CHEMICAL AGENTS AT ROCKY MOUNTAIN ARSENAL (RMA)

3.a. OPERATION: EMERGENCY RESPONSE

3.b. ESTIMATED DAILY PRODUCTION RATE: _____

4. ARSENAL ORGANIZATIONAL SYMBOL: SMCRM-SF

5. SOP NO.: SF-50-1 DATE: 25 APRIL 1988

5.a. REV NO.: 1 DATE: 25 APRIL 1988

5.b. CHANGE NO.: _____ DATE: _____

6. AUTHORITY: AMC-R 385-131 / AR 50-6 DATE: 9 OCT 1987 / 12 NOV 1986

7. PREPARED BY: Alma T. Harris
ALMA T. HARRIS
TITLE: SAFETY & OCCUPATIONAL HEALTH MANAGER
TELEPHONE: 303-289-0336

8. REVIEWED BY: William Moloney
WILLIAM MOLONEY
TITLE: QUALITY ASSURANCE OFFICE

REVIEWED BY: Martin L. Wittig
MARTIN L. WITTIG
TITLE: CHIEF, FIRE PREVENTION BRANCH

SUBMITTED BY: Alma T. Harris
ALMA T. HARRIS
TITLE: SAFETY & OCCUPATIONAL HEALTH MANAGER

10. CONCURRENCES:

OFFICE	SIGNATURE	TITLE
SMCRM-IS	David L. Kim	DIR, INSTALLATION SERVICES
SMCRM-TS	Elijah G. Jones	C, TECHNICAL SUPPORT OFFICE
SMCRM-SS	Ernest Lowell	C, SECURITY OFFICE
SMCRM-ISS	Thomas G. Jones	C, SYSTEMS OPERATIONS DIV
AMXRM-TO	Donald L. Bartieri	PM, TECHNICAL OPERATIONS
TECHNICAL ESCORT UNIT	Thomas M. Neary	TEU COMMANDER
SMCRM-ISF	Donald T. Smith	ENVIRONMENTAL COORDINATOR
SMCRM-SF	Alma T. Harris	SAFETY MANAGER

SOP COVER SHEET

11. APPROVAL:

OFFICE	SIGNATURE AND DATE	TITLE
SMCRM-CO	Edward R Ettner 17 June 88 EDWARD R. ETTNER, JR.	COMMANDER, RMA

12. QUARTERLY REVIEW:

DATE	SIGNATURE	TITLE

13. SEMIANNUAL REVIEW:

DATE	SIGNATURE	TITLE

14. BIENNIAL REVIEW:

DATE	SIGNATURE	TITLE

(CONTINUED)

SUPERVISOR'S STATEMENT

SOP No. SF-50-1 REV No._____ CHANGE No._____ DATE_____

1. The Supervisor will sign this statement:

   a. When first assigned as supervisor of the operation;

   b. When an approved formal or interim change is made to the SOP;

   c. At least once per quarter during simulation exercises;

2. I have personally reviewed each of the operational steps of this SOP and have no question in my mind that the operation can be performed safely, efficiently, and in an environmentally acceptable manner. I have trained the operators in the details of their part of the operation and have instructed them to follow the SOP without deviation.

SUPERVISOR:

(1)_____	_____	_____	
ECC COMMANDER	DATE	SIGNATURE	
(2)_____	_____	_____	
TEU COMMANDER	DATE	SIGNATURE	
(3)_____	_____	_____	
	DATE	SIGNATURE	
(4)_____	_____	_____	
	DATE	SIGNATURE	
(5)_____	_____	_____	
	DATE	SIGNATURE	
(6)_____	_____	_____	
	DATE	SIGNATURE	
(7)_____	_____	_____	
	DATE	SIGNATURE	
(8)_____	_____	_____	
	DATE	SIGNATURE	

OPERATOR'S STATEMENT

SOP No. SF-50-1 REV No._____ CHANGE No._____ DATE_____

1. The operator will sign this statement:

   a. When first assigned to the operation;

   b. When an approved formal or interim change is made to the SOP;

   c. At least once per quarter during simulated exercises;

2. I have read or have had read to me and understand the general and specific safety and environmental requirements, personnel limits, work description, and inspection requirements necessary to accomplish my operation. I have been thoroughly trained in, and am familiar with, my part of the operation and I agree to abide by these instructions throughout my assignment to the operation.

OPERATOR:

(1)_____	_____ DATE	_____ SIGNATURE	
(2)_____	_____ DATE	_____ SIGNATURE	
(3)_____	_____ DATE	_____ SIGNATURE	
(4)_____	_____ DATE	_____ SIGNATURE	
(5)_____	_____ DATE	_____ SIGNATURE	
(6)_____	_____ DATE	_____ SIGNATURE	
(7)_____	_____ DATE	_____ SIGNATURE	
(8)_____	_____ DATE	_____ SIGNATURE	

EMERGENCY RESPONSE PLAN FOR FIELD ACTIVITY DISCOVERED CHEMICAL AGENTS

TABLE OF CONTENTS

This SOP supersedes SMCRM-DC, DC-R-50-1, 13 May 87.

1. GENERAL SAFETY REQUIREMENTS

a. This SOP shall be available in the Emergency Control Center (ECC), Decontamination Truck, and other available places/areas as appropriate during this operation. All Emergency Response personnel shall maintain copies of this SOP and be responsible for carrying out its provisions.

b. There will be no deviation or change to this SOP without prior approval of the Installation Commander or his designated representative.

c. Care will be taken to limit exposure to a minimum number of personnel, for a minimum amount of time, to a minimum amount of hazardous material consistant with safe and efficient operations.

d. Personnel lifting material will use proper, safe lifting procedures, avoid twisting when lifting or carrying, and avoid sharp objects.

e. Protective Clothing and Equipment will be worn by all individuals as designated by their position of response.

f. No smoking, eating, or drinking should occur during this emergency response. (There may be some areas excluded, i.e., ECC.)

g. HEATSTROKE is a Medical Emergency. Immerse victim in cool water while waiting for the ambulance. Massage arms and legs to aid circulation. If unable to immerse victim, soak his clothing in water and rush him wet to a hospital. DO NOT TRY to give water to an unconscious victim.

NOTE: Prior designation of an Emergency Response Command Structure is highly recommended to avoid confusion and misdirection at the scene.

2. SCOPE. This SOP outlines the responsibilities for the RMA Emergency Response Team to follow whenever a chemical accident/incident occurs at this installation. This SOP will be added as an Appendix to the contractor's Safety and Health Plans.

3. RESPONSIBILITIES:

a. The Commander (Cdr), RMA, will:

(1) Be in complete command and control of all personnel, equipment, and procedures within the operational site.

(2) Provide appropriate level protective clothing for all emergency response personnel. [The source of supply is the ISSA (Intra Service Support Agreement) with Pueblo Army Depot.]

(3) Designate a Chemical Accident/Incident Response Officer (CAIRO) to conduct actions In Accordance With (IAW) this SOP. (When the Technical Escort Unit (TEU) are here, they will be the CAIRO.)

b. The CAIRO will:

(1) Initiate actions based upon this SOP to limit the spread of contamination and to prevent personnel becoming chemical casualties.

(2) Set up and control operations in and around the site from a mobile Command Post (CP) located upwind of the site at a safe distance based upon the particular circumstances of the accident/incident/occurrence.

(3) Determine the facts regarding the accident/incident/occurrence, and make appropriate recommendations as to response actions needed to the Cdr, RMA. Take actions as approved. In the absence of the Cdr, RMA, take actions considered necessary and appropriate.

(4) Advise and provide operational support to an AMC General Officer (On-Scene Commander) if one arrives at the Installation.

c. The Chief, Fire Department (Dept), RMA, will:

(1) Arrive on-site and assume full responsibility as the Assistant CAIRO (A/CAIRO) until arrival of CAIRO. Accomplish the immediate decontamination/treatment/evacuation of casualties from the site, and limit access onto the site to personnel needed for emergency response actions.

(2) Provide Emergency Medical Technician (EMT) and Firefighting/Rescue (FF/RS) teams to perform emergency response actions on site.

d. The Chief, Security Office, RMA, will provide security guards to establish Traffic Control Points (TCP) which will limit access of the site to persons needed for emergency response only.

e. The Chief, Technical Support Office (TSO), RMA, will:

(1) Provide chemical surety laboratory (lab) analysis on all suspect water and soil samples. Provide monitoring with bubblers for suspect contaminated equipment to determine if further decontamination is warranted prior to release.

(2) Provide results of analysis to the CAIRO for use at the operational site as soon as possible.

(3) Provide an individual to work with the Senior Quality Assurance personnel on the Downwind Hazard Monitoring Team.

(4) Provide a trained individual to operate the Downwind Vapor Hazard Distance (DWVHD) Calculator.

f. The Senior Quality Assurance (QA) personnel , RMA, will:

(1) Be the lead person for the Downwind Hazard Monitoring Team. (The other team members will be assigned at that time.)

(2) Provide training in the use of the M18A2 Chemical Detection Kit to members of the monitoring team.

g. The Director, Installation Services (DIS), RMA, will:

(1) Provide a two person monitoring team trained to monitor beyond the DWVHD downwind of an operational site.

(2) Provide downwind hazard monitoring outside the DWVHD downwind of an operational site.

(3) Provide on-site monitoring for chemical surety materials.

h. The Safety Manager, RMA, will report all accidents/ incidents/occurrences to higher headquarters, i.e., PM as outlined in AR 50-6, and AR 385-40 to include appropriate supplements.

i. The Public Affairs Officer (PAO), RMA, will, if applicable, notify higher headquarters, i.e., PM as required by AR 360-5; and at the direction of the Cdr, RMA, will determine when to disclose information to the public.

j. The Chief, Systems Operations Division, will:

(1) Provide a trained and knowledgeable personnel decontamination team, comprised of other Arsenal elements, to respond to emergency situations in the event TEU is not available at RMA.

(2) Be the CAIRO when TEU is not available at RMA.

(3) Provide personal protective clothing and equipment to all RMA Emergency Response members.

k. The Contractor's On-Site Safety Officer (OSO) will:

(1) Provide the mini Decon and central shower system for his particular operations.

(2) Ensure that contractor personnel's Site Safety Procedures interface with this Emergency Response SOP.

(3) Ensure provisions are made for some (minimum 2) contractor personnel to remain on site at a predesignated location (at least 50 meters upwind) until RMA or Technical Escort Unit (TEU) emergency response team arrives so that information can be relayed to the emergency response teams.

(4) Ensure proper protective measures are utilized by contractor personnel on each operational site, to include protective clothing worn and removed properly for decontamination; chemical detection equipment and core sample heaters utilized correctly; and all equipment secured on site until site has been cleared by RMA emergency response actions in the event chemical contamination is suspected.

(5) Upon two consecutive positive readings with the M-18A2 during drilling or soil sampling operations, ensure all personnel within 150 feet of the drill/sample site and where the sample was tested move to a predetermined site upwind and thoroughly decontaminate their outer clothing. The RMA Fire Department will be called to initiate an emergency response.

(a) Have the crew immediately transported in a vehicle with a removable bed liner to the contractor support area where they will process through the hot line to the showers. Clothing and equipment will be double-bagged and held; wash water will be retained. Personnel will be observed throughout the process for symptoms of agent exposure.

(b) Return to the site if subsequent laboratory analysis of the suspect soil is negative. If the analysis is positive, the decontamination procedures of this SOP will apply. If the vehicle bed liner and contractor shower trailer are found to be contaminated, they will be decontaminated and retained under Army control.

(6) If contact with liquid or vapor agent is suspected, the contractor will move upwind to their mini-decon location, perform first-level decontamination and removal of outer clothing, and then be transported for further decontamination as appropriate. Rocky Mountain Arsenal personnel will control contaminated clothing until such time that laboratory analysis indicates negative results.

(7) After contractor personnel are transported to the central shower area, they will remain at a designated location for necessary observation for signs and symptoms of agent exposure. Observation by the supervisor or designated authority is necessary before allowing personnel to leave the installation, unless laboratory analysis of samples proves negative. In addition, the transport vehicle will be considered suspect contaminated until such time monitoring results prove negative. If positive readings are encountered, the transport vehicle will be decontaminated to the 3X level and appropriately marked in accordance with AMC-R 385-131. The transport vehicle must remain upwind of the operational site (a least 50 meters) to preclude the possibility of the vehicle becoming contaminated prior to its use.

1. The TEU/EOD Project Officer (OIC) will:

(1) Serve as the CAIRO of RMA when on Post.

(2) Obtain overall guidance from the Commander, TEU, Aberdeen Proving Ground, Maryland.

(3) Provide a summary of operations conducted to the Program Manager (PM), the Cdr, RMA, and the contractor involved.

(4) Have operational command and control over all personnel directly involved in the operations downrange.

(5) Be responsible for the execution of all TEU operations.

(6) Conduct a briefing for all personnel involved in down-range operations and reemphasize safety precautions to be taken.

(7) Ensure a copy of this SOP and other applicable publications are readily available in a conspicuous place at the command post.

(8) Coordinate with TEU S4, PM, and RMA for acquisition of necessary military unique supplies to complete operations.

(9) Ensure radio/telephone contact with CAIRO on site is maintained during all operations.

(10) Ensure that the required personnel, equipment, and decontaminants are on-hand before starting operations.

(11) Be responsible for establishing the hotline.

(12) Ensure that a log (DD Form 1594) of operations is kept.

m. The Decon Team Hot Line Supervisor (TEU NCOIC when on post) will:

(1) Ensure that all personnel are prepared and ready for work upon arrival at the work site at the time designated by the OIC.

(2) Ensure that each individual has been briefed on the hazards of the operations and that the SOP has been read, understood, and signed by all personnel concerned.

(3) Ensure that substitutes for the operational teams are available when required.

(4) Ensure that all operational personnel have received a daily safety briefing before they are involved in any operations.

(5) Ensure that all equipment will be operated by licensed personnel.

(6) Ensure that all downrange personnel have had their protective masks fit checked with amyl acetate (banana oil).

(7) Ensure the CAIRO has TEU radio net and RMA Charlie net, as necessary.

n. The TEU personnel will perform procedures as directed by the OIC.

o. The individual workers will:

(1) Follow protective measures outlined in this SOP and any other applicable SOPs in order to prevent the spread of contamination and to prevent becoming a chemical casualty.

(2) Inform supervisor of any change in health status, particularly during and after operations occur.

4. HAZARDOUS CHEMICALS. In all cases, the RMA Fire Prevention Branch will, after initial decontamination, evacuate the victim immediately to the Fitzsimons Army Medical Center (FAMC) Emergency Room (ER). They will ensure the FAMC ER is notified of the incoming casualty by the most expeditious communication method available.

a. HTH (Calcium Hypochlorite).

(1) HTH is a bleaching material available as a stable, water-soluble material in a granular form. The compound contains between 70% and 30% available chlorine and is very corrosive. HTH is satisfactory for the decontamination of V and H agents. Do not use pure HTH on H, since a toxic vapor and/or a fire can be produced.

(2) HTH will destroy clothing, has a toxic vapor, and will burn the skin. A protective mask and rubber gloves are the minimum protective equipment for handling HTH. If HTH comes in contact with the skin or clothing, the area should be flushed with large amounts of water.

(3) HTH bleaches out the enzyme detector ticket. To confirm decontamination, use M8 detector paper for VX and the Blue Band Tube/Green Top Bottle for G series agents. Use Blue Band Tube/Blue Top Bottle for H series agents.

(4) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

b. STB (Super Tropical Bleach).

(1) STB is a bleaching material available as a stable, water-soluble material in a powder form. The compound contains between 35% and 10% available chlorine and is very corrosive. STB is used primarily in slurry pans. Do not use pure STB on H, since a toxic vapor and/or a fire will be produced.

(2) STB will destroy clothing, has a toxic vapor, and will burn the skin. A protective mask and rubber gloves are the minimum protective equipment for handling STB. If STB comes in contact with the skin or clothing, the area should be flushed with large amounts of water.

(3) STB bleaches out the enzyme detector ticket. To confirm decontamination, use M8 detector paper for VX and the Blue Band Tube/Green Top Bottle for G series agents. Use Blue Band Tube/Blue Top Bottle for H series agents.

(4) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

c. Soda Ash (Sodium Carbonate - Washing Soda).

(1) Soda Ash is a white powder having alkaline properties.

(2) Soda Ash is used for decontamination purposes at the personnel decontamination station (PDS) and is an effective decontaminant for G agents.

(3) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty, if necessary.

d. Caustic Soda (Sodium Hydroxide).

(1) Caustic Soda is the primary decontaminant for G series agents.

(2) Caustic Soda should be mixed in an iron or steel container, never in an aluminum one.

(3) Add Caustic Soda to water to prevent boiling and spattering due to the excessive heat emitted.

(4) Caustic Soda can cause skin burns.

(5) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

NOTE: Caustic Soda is not in the list of required materials. Use Soda Ash instead.

e. Nerve Agents (GB, GD, GA, VX).

(1) GB, GD, and GA are colorless liquids with a high boiling point and a very low freezing point. They are considered non-persistent, lethal chemical agents.

(2) VX is a straw-colored liquid with an extremely high boiling point and a very low vapor pressure. It is considered a persistent, lethal chemical agent.

(3) Nerve agents are rapid-acting, lethal chemical agents. The action of the agent within the body is the inactivation or inhibition of cholinesterase. The hazards from nerve agents are that of vapor absorption through the respiratory tract, absorption through any part of the skin, through the eyes, and through the gastrointestinal tract by ingestion.

(4) Accidental skin contact with the liquid agent or inhalation of agent aerosol or vapor are the most common causes of casualties. The agent absorption rate is accelerated through cuts or abrasions in the skin.

(5) Symptoms - Initial:

(a) Pinpointing of pupils (myosis) and dimness of vision.

(b) Running nose.

(c) Tightness of chest.

(d) Difficulty in breathing.

(e) Liquid contact produces, in addition to the above symptoms, localized sweating and twitching in the muscles beneath the exposed area.

(6) Symptoms - Advanced.

(a) Nausea and possible vomiting.

(b) Cramps and involuntary urination and/or defecation.

(c) Headache or drowsiness.

(d) Coma.

(e) Convulsions.

(f) Cessation of breathing.

(7) The casualty will be decontaminated. After decontamination of the eyes by immediately flushing with water and decontaminating the face, the victim will be masked. Contaminated clothing will be removed. Contaminated areas (except eyes) will be washed with commercial liquid household bleach (Sodium Hypochlorite - nominal 5% solution) and flushed immediately with water. Decontamination will be completed, if possible.

(8) If there is no apparent breathing, CPR will be started immediately. Mechanical resuscitation will be used by the EMTs if facial contamination is present.

(9) One (1) Nerve Agent Antidote Kit (NAAK), MARK 1, will be given immediately by intramuscular injection to an individual upon onset of symptoms or signs of agent exposure.
NOTE: Although myosis (pupil contraction) is a sign of nerve agent exposure, the MARK 1 kit will not be given when this is the only symptom present (IAW DARCOM Reg 385-102).

(10) One MARK 1 injector dose may be repeated at 10-15 minute intervals if indicated by the continuation of nerve agent symptoms. No more than three (3) doses will be given without the advice and approval of a physician. A record of the doses will be kept with the casualty.

(11) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

f. Mustard (H, HD, HT - Blister Agents).

(1) Mustards are oily liquids ranging from colorless to dark brown in color. They have a characteristic odor similar to garlic or horseradish. Mustards freeze at approximately 58 degrees Fahrenheit, are stable in storage to 252 degrees Fahrenheit, and have no action on metals.

(2) Mustards are delayed-action, persistent, toxic chemical agents that burn and blister the skin or injure the internal parts of the body. Main portals of entry into the body are by inhalation of the vapors, by liquid contact with the skin, or through any body opening.

(3) Persistence of the hazard from mustard is dependent upon the concentration of the agent and the temperature. It will persist two to five times longer in the winter than in the summer.

(4) Mustard has a cumulative effect even in small repeated exposures and may produce a sensitization in some individuals. If this occurs, the individual will exhibit allergic symptoms and will react to even small doses.

(5) Symptoms.

(a) Little or no pain occurs upon exposure to mustards. The first symptoms appear 4 to 6 hours later.

(b) Eyes are extremely sensitive to low concentrations of mustard and become inflamed, causing "red eye" and a sensation of grit in the eyes.

(c) When exposed to heavy concentrations, the nose and throat become inflamed, causing the sensation of having a head cold.

(d) The skin reddens and water blisters may develop if the individual contacts liquid mustard.

(6) After exposure to a mustard agent (H, HD, HT, or L), flush eyes and face with copious amounts of fresh water. Blot contamination from the skin - DO NOT RUB OR SCRUB!

(7) Remove the person from the source of the contamination and flush the skin and clothes with a 5% Sodium Hypochlorite solution within one (1) minute of exposure. Remove the contaminated clothing. Flush the skin again with a 5% Sodium Hypochlorite solution. Wash contaminated skin with soap and water. If showering facilities are not immediately available, use the skin decontamination pads found in the M258A1 Decontamination Kit.

(8) For gross contamination of the skin, the contaminated area should be flushed immediately with clear, cool water, avoiding rubbing the affected area. As soon as possible, the individual should shower.

(9) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

g. Lewisite (L - Blister Agent).

(1) Lewisite is an oily liquid ranging from colorless to violet in color. It has a characteristic odor similar to that of geraniums. Lewisite freezes at 0 degrees Fahrenheit, and has no action on metals if it is dry.

(2) Lewisite is a rapid-acting, non-persistent, toxic chemical agent that burns and blisters the skin or injures the internal parts of the body. Main portals of entry into the body are by inhalation of the vapors, by liquid contact with the skin, or through any body opening.

(3) The persistence of the hazards from Lewisite is dependent on the concentration of the agent and the temperature. It decomposes rapidly in hot, humid weather.

(4) Lewisite has a cumulative effect on the body and acts as a systemic poison.

(5) Symptoms:

(a) Lewisite produces an immediate, strong, stinging sensation to the skin. Reddening of the skin is evident within thirty (30) minutes.

(b) Eyes are extremely sensitive to liquid Lewisite and sight loss will occur if they are not decontaminated within one (1) minute.

(c) High concentrations of Lewisite cause pulmonary edema, diarrhea, subnormal temperature, and low blood pressure.

(6) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

NOTE: Decontamination and treatment of Lewisite casualties is IAW paragraph 3f(7) - (9) above.

h. Hydrogen Cyanide, Cyanogen Chloride (AC, CK - Blood Agents).

(1) Blood agents are absorbed into the body primarily by breathing. They affect the bodily functions through action on the enzyme cytochromeoxidase, thus preventing the normal transfer of oxygen from the blood to the body tissues.

(2) Blood agents are rapid acting casualty-producing agents which have a short duration of effectiveness due to the high volatility of the agents.

(3) CK has the additional capability of breaking down the filter elements of the protective mask.

(4) Symptoms:

(a) Increased breathing rate. (AC) Rapid or shallow breathing, depending on type.

(b) Decreased breathing rate. (CK).

(c) Increased pulse rate and pounding heart.

(d) Lips and skin will flush pink to red because of the excessive oxygen in the blood.

(5) After exposure to a blood agent, evacuate the casualty immediately to the FAMC ER.

(6) Artificial respiration may be needed if breathing becomes difficult.

(7) Decontamination procedures for AC and CK is to wash with copious amounts of water. However, the agent has a rapid evaporation factor making field decon ineffective.

(8) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

i. Adamsite (DM - Vomiting Agent).

(1) DM is a greenish--yellow powder to black solid with no apparent odor.

(2) DM has a very high rate of action and requires only about one (1) minute to incapacitate an individual.

(3) Symptoms:

(a) Irritation to the eyes and mucous membranes.

(b) Runny nose.

(c) Sneezing.

(d) Coughing.

(e) Severe headaches and acute pain.

(f) Tightness in the chest.

(g) Nausea and vomiting. The effects may last up to three (3) hours.

(4) After exposure to a vomiting agent, vigorous activity will lessen the duration of the effects of this agent.

(5) Decontamination procedures -- remove victim to fresh air. A 5% sodium hypochlorite and water solution (bicarbonate of soda) should be used to wash away any detectable DM.

(6) Transport the casualty to the FAMC ER immediately. Notify the ER of the incoming casualty.

j. Phosgene (CG - Choking Agent).

(1) CG is a delayed-action chemical agent which is absorbed by the lung air sacs and then hydrolyzed. This irritation damages the capillaries and causes blood plasma to fill the lungs causing "dry land drowning".
WARNING: CG can defeat the protective mask in a short period of time.

(2) Symptoms:

(a) Initial - May vary from none to severe (coughing, nausea, or headache).

(b) Advanced - Tightness in the chest, painful shallow breathing, and coughing up a frothy sputum.

(3) After exposure to a choking agent, keep the casualty calm and warm.

(4) Aeration is the primary decontamination; however, the area of the face/mask may be washed with copious amounts of water. Caustic solution may be used to decon liquid CG. (Ammonia hydroxide mist may be used for leak detection.)

(5) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

k. BZ.

(1) BZ is a slow-acting incapacitating agent. Action of the agent within the body is the depression of the central nervous system. The hazards of BZ are from inhalation or ingestion.

(2) Sypmtoms: (after 1 to 4 hours).

(a) Restlessness.

(b) Dizziness.

(c) Confusion.

(d) Vomiting.

(e) Dryness of the mouth.

(f) High temperature (sometimes above 102° F *, p. 6)

(g) Flushing of the skin.

(h) Blurred vision.

(i) Dilation of the pupils.

(j) Slurred speech.

(3) After exposure to an incapacitating agent, keep the casualty calm, restrained; may need cooling as for heat stroke*.

(4) Decontamination of personnel can be accomplished by washing contaminated parts with soap and water. Flush eyes with clear water only. Clothing and individual equipment should be shaken or brushed and thoroughly washed. Hypochlorite or alcohol caustic solutions are suitable for deconning.

(5) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

1. White Phosphorous (WP) and Red Phosphorous (RP).

(1) WP and RP are bursting smokes which ignite spontaneously when they come in contact with air. The vapors of WP and RP are poisonous, and exposure causes bone decay. (No vapors are found in smoke.)

(2) WP and RP should be moved and stored under water to prevent spontaneous combustion.

(3) Symptom: Severe burns which could take a long time to heal.

(4) After exposure to WP or RP, keep the casualty calm and keep the affected area under water.

(5) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

5. SPECIFIC SAFETY REQUIREMENTS.

a. Before being assigned to emergency response operations, RMA personnel will be given a medical examination IAW AMC Reg 385-131, DA PAM 40-8, and OSHA standards. The preassignment medical examination will include blood cholinesterase tests IAW current policy to establish a baseline level. Each person who is assigned to hazardous operations will be given a medical examination at least annually and at any other occasion when the medical authority deems it advisable.

b. Other personnel and visitors who have a need to monitor or inspect RMA emergency response operations will have established a baseline cholinesterase level and have a record of it on file at the FAMC, or other medical monitoring program. This will be completed prior to visiting the operational area.

c. In cases of agent exposure, cholinesterase determinations will be made to measure the degree of anticholinesterase activity. Follow-up examinations of plasma and RBC cholinesterase content will be performed at the discretion of the medical officer.

d. Prior to assignment to operations at RMA contractor sites, the contractor personnel will be thoroughly briefed in the signs and symptoms of agent/contaminant exposure, by their Safety and Health personnel, as well as being instructed in first aid and self-aid techniques for exposure to the various agents/contaminants that they will be working with.

e. All personnel involved in operations at RMA suspect hazardous sites will be given an off-duty telephone number (289-0190/0192) to which suspect exposures can be reported to the RMA Fire Dept EMTs.

f. Any illness or sickness will be reported by the individual to the supervisor prior to the start of daily operations or before leaving the job, if the illness occurs during working hours.

g. Individuals requiring entrance to the suspect sites at RMA and having any cuts or abrasions on their person will inform his/her supervisor. These individuals will be referred to qualified medical personnel, prior to being permitted in the hazardous waste site, for assurance the cuts or abrasions are properly covered for the type of work to be accomplished.

h. All protective clothing worn by individuals or used during the operation will be serviceable and wear dated.

i. Protective masks will be serviceable and fit checked prior to use during operations.

j. Training exercises will be conducted utilizing procedures for personnel decontamination (See Appendix A and Figure 1).

SOP No.	SF-50-1	DATE	25 Apr 88
Rev No.	1	DATE	25 Apr 88
CHANGE		DATE	

6. INDEX OF OPERATIONS

REMARKS:

a. This SOP prescribes policies and procedures for emergency response actions to be taken at Rocky Mountain Arsenal (RMA). These emergency response actions will support drilling and sampling operations conducted by government and contractor personnel; liquid sampling and area clearance operations conducted by Technical Escort/Explosive Ordinance Detachment (TEU/EOD) personnel; and any other future operations conducted at RMA in which potential for exposure to a chemical surety material exists.

b. The majority of contractors physically working on RMA are supporting the Remedial Investigation (RI) being conducted by the Program Manager for Contamination Cleanup, RMA. The two primary contractors are EBASCO and ESE. Both contractors are involved in drilling soil samples and pulling water samples from the thousands of wells located on RMA.

(1) Morrison-Knudsen Engineers is one of the contractors conducting an RI of contamination on RMA for Shell Chemical Company. This firm does its own collection of soil and water samples, as well as receiving splits of samples taken on RMA by EBASCO and ESE.

(2) Each contractor has numerous subcontractors who fulfill some portion of their contracts on RMA. The contractors, as well as their subcontractors, are responsible for adhering to the procedures outlined in this SOP for the health and safety of all concerned.

c. The Program Manager is responsible for the overall health and safety of contractors working for them. Any changes made by contractors which may affect the health and safety of their employees should be coordinated with the Program Manager and the RMA Safety Manager.

d. Appendix B identifies the procedures to be used should a suspected munition or other hazardous material be found on this installation/post.

e. Appendix D identifies a list of industrial chemicals found on RMA that the contractors are likely to become involved with.

REFERENCES:
AMC-R 385-100
AMC-R 700-107
AR 50-6
RMA-R 385-1

A. STANDING OPERATING PROCEDURE FOR Emergency Response by Rocky Mountain Arsenal (RMA) Personnel and TEU/EOD Personnel (when on post)

B. OPERATION 1
C. LOCATION RMA
D. SOP No. RM-SF-50-1
DATE 25 Apr 88
E. REV No. 1 DATE 25 Apr 88
F. CHANGE No. ___ DATE _____

G. OPERATION: Sampling and/or Area Sweeps

H. EXPLOSIVES LIMITS: N/A

I. PERSONNEL LIMITS: Available Personnel on the current TDA

J. STEP NO./DESCRIPTION	SPECIFIC INSTRUCTIONS (Safety (S), Operational (O), Quality Checks (QC))
1. Pre-Operation & During Operation. The supervisor of each operational site will ensure actions are IAW approved SOPs and Safety Plans.	1 (O). OSO/OIC will designate the location of the CP at least 50 meters upwind of the operational site, and will relocate the CP as needed. 2 (O). OSO/OIC will establish and maintain telephone and/or radio communications with the RMA Fire Dept. 3 (QC). OSO/OIC will appoint a CP recorder who will maintain a daily log of all operations to be given to the CAIRO if emergency response actions become necessary. 4 (S). Personnel should know the proper protective equipment to be worn, the proper decontamination techniques to be performed, the methods to limit the spread of potential contamination, and the actions to be taken upon finding a positive test for chemical surety material.

NOTE: Personal Protective Clothing & Equipment (PPC&E) can be found in paragraphs K and L. Levels of PPC&E can be found in AMC-R 385-1, Chapter 4.

J. STEP NO./DESCRIPTION	Specific Instructions (Safety(S), Operational(O), Quality Checks(QC))
2. Termination of Operation. Upon finding a positive test for chemical surety material, operations will cease on site, and emergency notification will begin. [See Figure 1]	1 (O). Upon finding a positive reading for chemical surety material with OV/HNU/M8/M18A2 detectors, all operations stop. 2 (O). OSO/OIC will verify the positive reading with an M18A2 Chemical Agent Detector Kit. If test is negative, resume operations. If test is positive, begin the emergency response by calling the RMA Fire Dept., Ext.223. 3 (O). OSO/OIC will direct on-site personnel to decontaminate their clothing, and proceed to the Contractor's Support Area for processing through the hot line IAW paragraph 2k, page 10. 4 (S). OSO/OIC will observe personnel closely in a shaded area for signs/symptoms of chemical agent exposure and/or heat prostration. 5 (O). All individuals will take appropriate first aid measures for either chemical agent or heat casualties. 6 (O). OSO/OIC will direct all equipment, soil and water samples are to remain on-site. 7 (O). Soil samples found to contain surety material after being placed inside the core heater will not be distributed. These will be monitored by RMA QA personnel; and if positive, will be transported by them directly to the RMA Lab for chemical surety analysis.
3. Limited Emergency Response Actions. a. These actions will be performed by RMA employees in response to notification of a positive reading for chemical surety material.	1 (O). Upon notification of a positive test, the RMA Fire Dept. will notify the Command Office, QA Office and TEU (if on post) of the positive test and the location of the contractor. 2 (O). The Fire Dept Chief, or the Senior Fire Officer, will proceed to

J. STEP NO./DESCRIPTION	Specific Instructions (Safety(S), Operational(O), Quality Checks(QC))
b. These actions will be a combined RMA-TEU response to any notification of a positive reading for chemical surety material.	the CP at the operational site to initiate measures to limit access to the area to authorized personnel only and to assume duties as the A/CAIRO. 3 (S). Until appropriate monitoring with an M18A2 kit has proven the initial test negative, all personnel will assume that the chemical agent is present and dress/perform accordingly. 4 (O). Upon arrival on-site, the QA monitoring team will coordinate with the A/CAIRO and the On-Site Safety Officer (OSO) to gather information before proceeding along with the A/CAIRO in appropriate level Protective Clothing onto the site to perform monitoring of samples, equipment, and bore holes. After providing the necessary information [Figure 3], and answering any additional questions, the OSO and any other contractor personnel will process off the site IAW paragraph 2k, page 10. Individuals will be observed closely for signs/symptoms of chemical agent exposure for at least 30 minutes after coming off-site prior to departing RMA for the day. 5 (O). If M18A2 tests by the Monitoring Team prove to be negative, the Monitoring Team will notify the A/CAIRO who will give the OSO permission to resume operations.
4. When TEU/EOD are on post they will contain hazards and establish a hot-line and PDS. They will also take samples for the Lab test.	6 (O). If the M18A2 kit tests prove to be positive for a chemical surety agent, the Monitoring Team will notify the A/CAIRO of the results and the agent present. The A/CAIRO will direct the personnel decontamition team to set up a PDS, notify the OSO of the positive test results for that particular chemical surety agent.

J. STEP NO./DESCRIPTION	Specific Instructions (Safety(S), Operational(O), Quality Checks (QC))
	7 (O). Depending on the amount of equipment on-site and the number of casualties (if any), the A/CAIRO will direct members of the EMT/FF/RS teams to assist the Monitoring Team in decontaminating equipment on-site, double-bagging all items, and sealing the bore hole with plastic to prevent further vapor hazard in open air. The A/CAIRO through the Fire Prevention Branch will notify the Laboratory.
	8 (O). Once the equipment has been double-bagged, and a sample has been taken to the RMA Lab for chemical surety analysis, the Monitoring Team will pass the double-bagged equipment through the PDS for transportation by truck to Building 882, seal with plastic any sample bore sites in the operational area, place appropriate markers on-site, and then process through the PDS off-site.
	9 (O). The Safety Manager and the PAO, RMA, will make the necessary reports (if applicable) up the chain of command within the prescribed time limits delineating the events which occurred.
5. Extensive Emergency Response Actions and RED PHONE ALERT	1 (O). The A/CAIRO will determine any additional response needed based upon the Monitoring Team recommendations. The A/CAIRO will notify the Security Desk Sergeant who will initiate a RED PHONE ALERT message requesting specified personnel comply with these actions.
	2 (O). When RED PHONE ALERT message comes through, the Emergency Response Team members will proceed to the Laundry for Masking, after which all personnel will take their assigned positions. (See Appendix C for Emergency Response Personnel List.)

J. STEP NO./DESCRIPTION	Specific Instructions (Safety(S), Operational(O), Quality Checks (QC))
	3 (O). The ECC members will proceed to the ECC to assume duties as assigned.
	4 (O). The CAIRO will proceed to the site with the ambulance and driver/ EMT.
	5 (O). The ECC will notify the Lab of possible incoming surety samples, and will notify members of the personnel decontamination team to respond IAW this SOP. He will notify the Downwind Vapor Hazard Calculator to proceed to the (ECC) to begin calculating the DWVHD for the chemical agent identified on site.
	6 (O). The Chief, Security Office, will dispatch a TCP Security Team to the operational site based upon the route of ingress onto the site provided by the A/CAIRO. The A/CAIRO will brief the TCP Security Team upon arrival on-site, and will direct the placement of the TCP based upon wind direction, suspected agent, and routes into and out of the operational area. The Chief, Security Office, then proceeds to the ECC to coordinate security operations on post.
	7 (O). The A/CAIRO will direct the required response level of EMT and FF/RS teams based upon circumstances on-site.
	8 (S). Once on-site, all Emergency Response personnel will remain at the CP designated, unless specifically directed to accomplish emergency rescue procedures downrange either while wearing Level A Protective Clothing or appropriate firefighting protective clothing and respiratory apparatus.

J. STEP NO./DESCRIPTION	Specific Instructions (Safety(S), Operational(O), Quality Checks(QC))
	9 (O). After receiving the DWVHD from the ECC, the CAIRO will dispatch the monitoring team in Level B Protective Clothing with mask worn to monitor areas just beyond the DWVHD to ensure no vapor hazards exist outside the DWVHD. The ECC must ensure no unprotected personnel are allowed to remain within the area covered by the DWVHD. The team should radio results and locations to the ECC, where these will be plotted to ensure no additional persons need to be evacuated.
	10 (O). The EMT rescue team remaining at the CP will observe contractor and RMA personnel in the CP, and treat any injuries which may occur.
	11 (O). Once the site has been cleared, and all personnel proceeding from the hot area are processed through the PDS, the CAIRO will determine if the TCP Security Team(s) can be released based upon the location of the site, and the safety factors involved.
	12 (O). The CAIRO will complete the initial report of the accident/incident/occurrence (Figure 3), and provide it to the Cdr, RMA.
	13 (O). The Safety Manager and the Public Affairs Officer (PAO), RMA, will make the necessary reports up the chain of command within the presribed time limits delineating the events which occurred.
	14 (O). All on-site personnel involved in the emergency response will be observed by EMTs, and if found to exhibit symptoms of chemical agent exposure, will be treated and transported immediately to the FAMC ER for follow-up treatment. Notify the FAMC ER of the incoming casualty, the chemical agent to which the patient was

J. STEP NO./DESCRIPTION	Specific Instructions (Safety(S), Operational(O), Quality Checks(QC))
	exposed, and the decontaminants used, by the most expeditious communications method available.
	15 (O). Once the site has been properly marked and all double-bagged protective clothing, contaminated soil, and equipment have been removed, the CAIRO will cancel the emergency response and allow all personnel to return to normal duties.
6. Follow-Up Requirements	1 (O). The Monitoring Team will monitor the double-bagged equipment with a minimum of one (1) each 2 to 3 hour lab bubbler to determine if contamination is present.
	2 (O). If the analyses show the equipment is no longer contaminated, it can be released to contractor personnel for use <u>on RMA only</u> since it will have been decontaminated to 3X level only. If the analyses show the equipment is still contaminated, the monitoring team will attempt to decontaminate and bubble the equipment again. If the equipment is still contaminated, the equipment will be held on RMA for future thermal decontamination.
	3 (O). Once the analyses of the samples are completed, the RMA Lab will furnish results to QA, Cdr, RMA, TEU (when on post), PM, and the contractor involved. If there are no detectable levels of chemical surety material present in the sample, it can be released to the contractor, and from the contractor to all other appropriate contractors/subcontractors. If there are detectable levels of chemical surety material present within the sample, the sample will not be released, and will remain in Building 882 until final disposal after approved decontamination.

J. STEP NO./DESCRIPTION	Specific Instructions (Safety(S), Operational(O), Quality Checks(QC))
	4 (O). All personnel, including contractor, RMA, and TEU employees, should monitor their health and watch carefully for any signs or symptoms of chemical agent exposure which may not appear until after normal duty hours. If symptoms seem to appear, the individual employee should telephone the EMTs at the RMA Fire Dept to report the symptoms to them (289-0190/0192). They will recommend that the individual proceed immediately to the FAMC ER for treatment. The EMTs will telephone the FAMC ER to report that an individual with specific symptoms is proceeding to their location for treatment.
	5 (O). The final report will be compiled, prepared, and distributed to the Cdr, RMA, the Contractor OSO, the TEU (if on post), and Program Manager, by the CAIRO. It should include: Contractor Report of Suspected Chemical Agent; DA Form 285 (see Figure 4); Lab results (if agent is detected); and CAIR After-Action Report.

K. SPECIAL REQUIREMENTS:

1. Equipment will be added or deleted as dictated by the situation and/or weather conditions at the discretion of the OIC/NCOIC/CAIRO.

2. First Aid Equipment: (located in the ambulance provided by RMA):

a.	Stretcher	2 ea
b.	Blanket, Wool	4 ea
c.	Water	5 gal
d.	Kit, First Aid, General	2 ea
e.	NAAK, Mark 1	6 ea

L. EQUIPMENT, TOOLS, GAGES, AND SUPPLIES:

	ITEM	QTY
1.	MATERIALS:	
a.	HTH (Calcium Hypochlorite)	350 lbs.
b.	Soda Ash (Sodium Carbonate - Washing Soda	350 lbs.
c.	Potable Water	20 gals.
d.	Household Bleach (Sodium Hypochlorite -5% Solution)	5 gals.
e.	STB	50 lbs.
2.	TOOLS/EQUIPMENT PER INDIVIDUAL:	
a.	Mask, Protective, M17A2	1 ea
b.	Mask, Protective, M9A1	1 ea
c.	Boots, Safety or TAP	1 pr
d.	Field Jacket or Parka, Cold Weather	1 ea
e.	Gloves, Butyl Rubber	1 pr
f.	Coveralls, Explosive Handler	1 ea
g.	Headgear	1 ea

h.	Wet Weather Parka and Trousers	1 ea
i.	Kit, Nerve Agent Antidote (Mark 1)	3 ea

3. VEHICLES:

a.	Truck, 4-Wheel Drive, 1/2 ton	2 ea
b.	Truck, Cargo, 2 1/2 ton Tactical w/Power Driven Decontamination Apparatus (PDDA)	1 ea
c.	Ambulance (provided by the RMA Fire Dept)	1 ea

4. CHEMICAL EMERGENCY KIT:

a.	Gloves, TAP	5 pr
b.	Boots, TAP	5 pr
c.	Footwear, TAP (Booties)	5 pr
d.	Hood, TAP, M3	3 ea
e.	Mask, M9 w/Filter	3 ea
f.	Undergarment, Impregnated	3 sets
g.	Gloves, Surgical	9 pr
h.	Coveralls, TAP	3 ea
i.	Coveralls, Explosive Handler	3 ea
j.	Apron, TAP	2 ea
k.	M6A2 Hood	2 ea
l.	Kit, Detector, M18A2	3 ea
m.	Water, 5 gallon Can	3 ea
n.	Bucket, 1 gallon	3 ea
o.	Tape, Masking	4 rls
p.	Bags, Plastic, Large & Small, 6 mil Thick	20 ea
q.	HTH	5 lbs
r.	Soda Ash	5 lbs

s.	Kit, Decontamination, Personal, M258A1	2 ea
t.	Brush, Toilet	2 ea
u.	Magic Markers	4 ea
v.	POP (Plaster of Paris)	10 rls

5. MISCELLANEOUS:

a.	Radio, Portable	6 ea
b.	Megaphone	2 ea
c.	Air Horn	2 ea
d.	Tape, Surveyors, Plastic	8 rls
e.	Stakes (2" x 1" x 4')	100 ea
f.	Hammer	2 ea
g.	Kit, Detector, M18A2	3 ea
h.	Probes, Non-Metallic	2 ea
i.	EOD Response Kit	1 ea
j.	Sand Bags (Prefilled)	20 ea
k.	.50 Cal Carts, Electric	10 ea
l.	Film, Color 5 x 7	10 pkg
m.	Camera, Polaroid	1 ea
n.	Prop Charge Cans Assorted Sizes (1-8" Prop Charge Can)	
o.	Fluorescent Orange Plastic Strips 1" x 6"	100 ea
p.	Chemical Agent Contamination Markers	50 ea

APPENDIX A

PROCEDURES FOR AN EMERGENCY PERSONNEL DECONTAMINATION STATION (EPDS)

STEP 1. Equipment Drop.

Equipment: Any material which prevents the contaminated equipment from contacting the ground, such as plastic bags or oilcloth; container with plastic bag liner for booties.

Action: Place all equipment used at the accident or incident site on the protective material. All movement across the hot line is through the slurry pan, if used. Remove booties, one at a time, and place booties in the container. Step across hot line on the grate over the sump.

STEP 2. Decontamination.

Equipment: Containers, preferably sprayers, for: decontaminant; hot, soapy water; and rinse water; decontaminant in sump, ABC M18A2 Detector Kit; first aid for agent(s) detected by Initial Entry Party (IEP) or Work Party (WP).

Action: Stand on grate over sump. Spray, pour, or brush each person's impermeable protective clothing with decontaminant. Spray, pour, or brush individual with hot, soapy water. Spray or pour rinse water on individual.

STEP 3. Clothing Removal.

Equipment: Plastic-lined container for protective clothing.

Action: Remove all clothing, except protective mask and hood, and place in the container. Continue to Step 4 which is at least 15 meters away.

STEP 4. Mask and Hood Removal and Shower.

Equipment: Plastic-lined container for protective mask and hood; container such as a 5-gallon can for wash water; grate for sump; towels.

Action: Step onto grate, take deep breath, and remove mask and hood and place in a container. Rinse head and upper body, then resume breathing, Pour water over body and wash with soap. Rinse body. Proceed across contamination control line to redress area.

Appendix A (continued)

STEP 5. First Aid and Redress.

Equipment: Extra clothing for personnel who are processed through the emergency PDS. First aid equipment to handle the emergency situation.

Action: Personnel have any injuries treated, dry off, and get dressed. They then go to the CP to wait for equipment and articles left at the PDS.

The IEP and WP should decontaminate as much of its own personal protection items and mission essential equipment as it can. Leave the area and the nonessential equipment to be decontaminated by support personnel.

The EPDS area is marked as contaminated, if required, until it is decontaminated by support elements.

FIGURE 1

EMERGENCY PERSONNEL DECONTAMINATION STATION (EPDS)

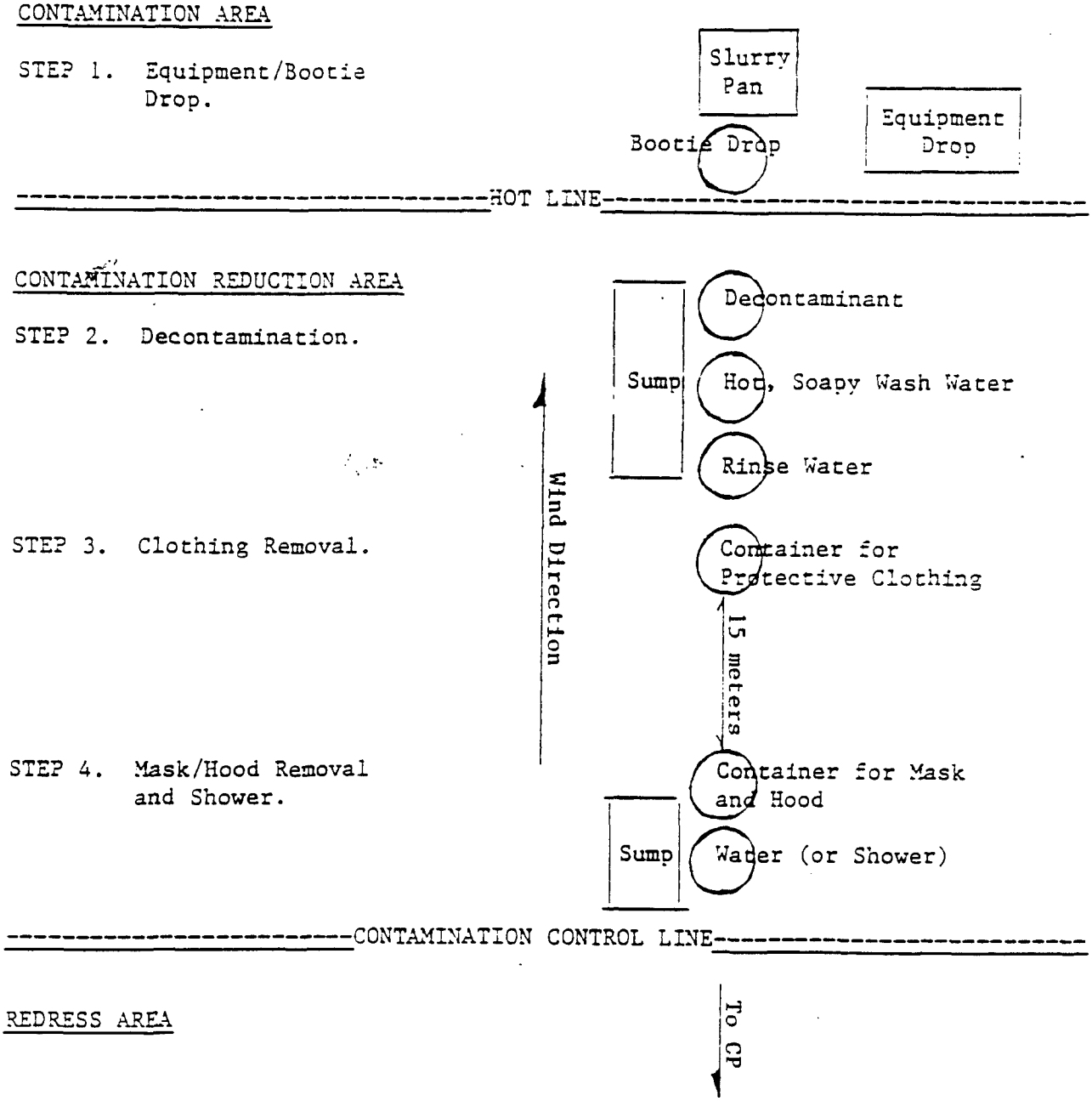


FIGURE 2

CONTRACTOR REPORT OF SUSPECTED CHEMICAL AGENT

DATE & TIME_____

Site Safety Supervisor:_____
Location:_____
Describe Activities in Progress:_____
_____
_____
Personnel Present:_____
_____
Notification to Fire Dept_____hrs _____/_____/_____

METHOD OF DETECTION

___Physiological Symptoms (describe):_____
_____
___Smell/Odor (describe):_____
_____
___M18A2 Detector Kit: Color of Tube Band_____
Number of Drops from which Bottle_____
Detector Ticket_____
Color Response of Tube or Ticket_____

___M8 Alarm
___M8 Detector Paper (color)_____
___HNU Photoionization Analyzer Model PI-101 (_____ppm)_____
___Foxboro OVA Model 128 (_____ppm)
___Other_____
_____

SAMPLE REPORT FOR CONTRACTORS

FIGURE 3

RMA FIELD RECONNAISSANCE AND MONITORING
FOR SUSPECTED CHEMICAL AGENT

Date & Time of Investigation: _____

Date & Time of Detection by Contractor: _____

RMA Personnel Conducting Field Investigation: _____

_____

_____

Describe Activities, Protective Clothing, Instruments, and Equipment:

_____

_____

Describe Monitoring Performed at Site: _____

_____

_____

Describe Observations and Action Taken: _____

_____

_____

Conclusion:

_____No Agent Found, Resume Operations.
_____Agent Found, Decontaminated, Resume Operations.
_____Agent Found, Area Isolated, No Further Operations.

Signature of TEU-OIC _____

Signature of Contractor OSO _____

Signature of CAIRO/A/CAIRO _____

INSTRUCTIONS FOR DA FORM 285

GENERAL. The unit having the accident must investigate it and complete this report. Complete only shaded items for nonfatal off-duty accidents not involving Army operations or materiel. For all other accidents, complete all items except those for safety staff or Safety Center use only. Type or print the report. Items may be continued on an attached sheet. Items not in the instructions are self-explaining.

1a. Enter the six-part unit identification code (UIC) of the unit having the accident.

1b. Enter the description of the unit. For example, enter HHC 2/34 Inf, 194 CAV, Yuma PG.

2. If unknown, estimate.

3. Dawn is between first light and official sunrise. Dusk is between official sunset and night.

4. "On Post" means the accident happened on property under Department of Defense control.

5. Enter facts needed to locate the accident scene. As needed, enter building number or direction and distance from closest landmark; enter street or highway name or number; enter city or military installation; enter state and country.

SECTION A — PERSONNEL INVOLVED

Complete this section for each person involved in the accident. "Involved" means a person who was injured or who caused or contributed to the accident. If more than one person was involved, use more forms and complete only this section on them. Witnesses and uninjured passengers are not considered involved. Be sure to also complete this section on each supervisor who caused or contributed to the accident. Give the supervisory error in item 30. In case of damage to property with no personnel involved (*e.g., fire, natural disaster*), report only items 6, 7 and 8 for the property custodian or the hand-receipt holder.

Give official address for all Government personnel. Leave out for all others. Include the unit UIC if different from the UIC in item 1.

3. Complete for all Government personnel. Leave out for all others.

9. Enter pay grade for all Government personnel including foreign national employees. For example, enter E6, 04, WG8, GS-12, O-3A. Leave out DEP all others.

10-13. Complete for Government personnel only. Leave out for all others.

14. "On Duty" means (*a*) person was at duty station during duty hours; or (*b*) person was away from duty station during duty hours but on official business. Leave out for non-Government personnel.

15-16. Complete for Government personnel only. Leave out for all others.

18. Enter this person's activity or task. For example, enter firing rifle, lifting box, walking across street, driving truck.

19-21. Leave out if activity (*item 18*) was not required for training. For example, exclude horseplay, chow run, stand down.

22. Pick the term below that best describes the overall mission of the activity or task in item 18.

Administrative: office	Medical
Maintenance: repair, services	Physical training; recreation
Transportation: supply, disposal	Food Services
Production: construction	Other operation
Research: development, testing	Personal: domestic
Emergency services: law enforcement	Off duty

23. The following definitions apply:

a. Permanent total disability means person can never again do gainful work.

b. Permanent partial disability means person loses or can never again use a body part.

c. Lost workday case - days away from work means person misses one or more days of work.

d. Lost workday case - restricted work activity means person is temporarily unable to perform regular duties.

e. Nonfatal case without lost workday means person (*1*) was permanently transferred or terminated, (*2*) received treatment greater than first aid, (*3*) lost consciousness, or (*4*) had an occupational illness that did not result in fatality or lost workday.

f. First aid only means one-time treatment of minor injuries.

24. Estimate the number of workdays this person will lose. Do not update this estimate unless this person dies.

25. Estimate the number of workdays this person cannot perform all regular duties after going back to work.

26. Describe this person's injury or occupational illness. For example, enter third-degree chemical burn, first-degree thermal burn, compound fracture, dermatitis, heatstroke concussion.

27. For the injury or illness shown in item 26, give the body part involved. For example, enter left knee, lungs, right thumb, nose.

28. Pick from the list below the event that resulted in the injury or illness. Then give the thing that produced it. For example, enter struck against *door*; bodily reaction due to *slip*; overexertion due to lifting *box*; exposure to *noise*.

Struck against ...	Bodily reaction due to ...
Struck by ...	Overexertion ...
Fall from elevation onto ...	Exposure to ...
Fall from same level onto ...	External contact with ...
Caught in/under/between ...	Ingested ...
Rubbed/abraded by ...	Inhaled ...

DA FORM 285, Aug 80

30. For each mistake this person made, pick one error from the list below. Use error in a sentence that includes the result of the error. For example, due to *improper attention*, SGT Jones did not yield the right of way to the other vehicle; PFC Smith made an *improper decision* to drive while under the influence of alcohol; Mr. English *failed to follow procedures (SOP)* and began spot welding without his safety goggles in place; due to *inadequate planning* by the company commander (*CPT Wright*), there was no unit ice and snow removal program. As a result, PFC Carr broke his arm by falling on the icy steps.

Inadequate inspection	Failed to comply with general rules/principles
Improper attention	Improper simple physical action (*lift, hold, drop, hit, push, pull, sit, stand, reach for, open, close, connect, disconnect, etc.*)
Failed to recognize	
Misjudged clearance/ speed/weight/size	
Misinterpreted	
Failed to anticipate	Improper complex physical action (*walk, run, crawl, climb, carry, jump, align, adjust, steer, brake, etc.*)
Inadequate planning	
Improper decision	
Inadequate improvising/ troubleshooting/ problem solving	Inadequate communication (*ask, answer, signal, inform, etc.*)
Failed to follow procedures/ orders/laws	

SECTION B — PROPERTY AND/OR MATERIEL INVOLVED

31a. List all property involved in the accident whether damaged or not. For example, enter Tank, M60A1. "Property involved" means materiel which is damaged or whose use or misuse contributed to the accident.

31b. Give ownership for each item listed. For example, enter Army, Air Force, Army National Guard, contractor, or private.

31c. If accident involved Army operations, enter estimated total cost of damage. Total will include costs of parts and labor.

32. For each materiel failure or malfunction, pick one type from the list below. Use the type in a sentence to tell how the materiel failed. Include nomenclature of materiel as in item 31. For example, M60A1 fuel line connector *vibrated* loose and sprayed fuel over engine causing fire; M1500M road grader fuel brake master cylinder rubber piston seal *decayed* and failed, causing loss of fluid and brake failure.

Overheated/burned/melted	Pulled/stretched
Froze (*temperature*)	Twisted/torqued
Obstructed/blocked/clogged	Compressed/hit/punctured
Vibrated	Bent/warped
Rubbed/worn/frayed	Sheared/cut
Corroded/rusted/pitted	Decayed/decomposed
Overpressured/burst	Electric current action (*short, arc, surge, etc.*)

33. TM 38-750 requires a Category I EIR for materiel failures or malfunctions that cause or contribute to accidents.

SECTION C — ENVIRONMENTAL CONDITIONS INVOLVED

34. For each environmental condition, pick one type from the list below. Use the type in a sentence that describes its role in the accident. For example, driver's vision was restricted by fog; air breathed was *contaminated* by toxic fumes; heat exhaustion resulted from high *temperature*; person slipped and fell on *floor* made *slippery* by wax.

Illumination (*dark, glare, etc.*)	Radiation (*sunlight, x-ray, LASER, etc.*)
Precipitation (*rain, fog, ice, snow, etc.*)	Work surface (*slippery floor, cluttered walkway, steep rough road, etc.*)
Contaminants (*fumes, dust, chemicals, FOD, etc.*)	
Noise	Air pressure (*explosion, decompression, altitude effects, etc.*)
Temperature/humidity	
Wind/turbulence	Electricity (*lightning, arc, surge, short, shock, etc.*)
Vibration	
Acceleration/deceleration	

SECTION D — DESCRIPTION AND CORRECTIVE ACTION

35. Give the sequence of events that describes what happened leading up to and including the accident. In describing the factors be sure to (*a*) name personnel making errors, (*b*) tell how involved personnel are related to materiel listed in item 31 e.g., passenger in M151A2 or lighting immersion heater, and (*c*) tell how environmental conditions affected personnel or materiel. Continue on an attached sheet if necessary.

37. This item is to be completed by the commander or his representative.

38. Command review as locally required.

SAFETY STAFF USE ONLY

GENERAL. The safety staff will complete this section on all accidents. The safety staff will investigate all accidents requiring a DA Form 285-1 and will attach it to this report.

39. When change is checked, items 1, 2, 6 and 8 must be completed plus any changes.

40. Enter MACOM of the unit shown in item 1. For example, enter FORSCOM, TRADOC, USAREUR, NGB or COE.

42. From the list below, select the type that best describes this accident. Types are listed in order of precedence to help pick one when more than one applies.

Army motor vehicle	Fire
Army combat vehicle	Chemical
Army aviation vehicle	Explosive
Privately owned vehicle	Missile
Marine diving	Radiation
Marine underway	Nuclear
Marine not underway	Personnel injury — other
Other Army vehicle	Property damage — other

43. Describe the type of vehicle collision. For example, ran off road and overturned, head-on collision, sideswipe, or vehicle struck pedestrian.

UNITED STATES ARMY ACCIDENT INVESTIGATION REPORT

For use of this form, see AR 385-40; the proponent agency is OCSPER.

REQUIREMENT CONTROL SYMBOL CSGPA-147(R&I)

NOTE: SPACES, BELOW, DEFINED BY HEAVY LINES ARE FOR "SAFETY CENTER USE ONLY."

1. UNIT IDENTIFICATION — a. UIC; b. DESCRIPTION

2. TIME AND DATE OF ACCIDENT — a. YEAR; b. MONTH; c. DAY; d. HOUR

3. TIME OF DAY (Check one) — ☐ a. DAWN ☐ b. DAY ☐ c. DUSK ☐ d. NIGHT

4. LOCATION — ☐ a. ON-POST ☐ b. OFF-POST

5. EXACT LOCATION OF ACCIDENT

SECTION A — PERSONNEL INVOLVED

6. NAME (Last - First - MI)

7. ADDRESS (Use military address for all Government employees)

8. SOCIAL SECURITY NUMBER

9. GRADE

10. AGE

11. SEX — ☐ a. MALE ☐ b. FEMALE

12. MOS OR CIVILIAN JOB SERIES

13. FLIGHT STATUS — ☐ a. YES ☐ b. NO

14. DUTY STATUS — ☐ a. ON DUTY ☐ b. OFF DUTY

15. NO. OF HOURS ON CONTINUOUS DUTY BEFORE ACCIDENT

16. NO. OF HOURS SLEEP IN LAST 24 HOURS (If hours on duty more than 8)

17. CLASSIFICATION AT TIME OF ACCIDENT (Check appropriate box)

☐ a. ACTIVE ARMY ☐ b. ARMY CIVILIAN ☐ c. ARMY CONTRACTOR ☐ d. NONAPPROPRIATED FUND ☐ e. OTHER U.S. MILITARY ☐ f. ROTC ☐ g. DEPENDENT

NATIONAL GUARD: ☐ a. TECH ☐ b. IDT ☐ c. AT ☐ d. ADT ☐ e. FTNG ☐ f. FTNI ☐ g. AGT

ARMY RESERVE: ☐ a. IDT ☐ b. AT ☐ c. ADT ☐ d. FTNI

FOREIGN NATIONAL: ☐ a. DIRECT HIRE ☐ b. CONTRACT HIRE ☐ c. KATUSA ☐ d. OTHER (Specify)

18. THIS PERSON'S ACTIVITY/TASK AT TIME OF ACCIDENT

19. IF THIS PERSON'S ACTIVITY WAS NECESSARY PART OF TRAINING, GIVE TYPE — ☐ a. BASIC (Schools) ☐ b. ADVANCED (Schools) ☐ c. OJT (Units) ☐ d. PROFICIENCY (Units) ☐ e. OTHER (Specify)

20. WAS THIS PERSON'S ACTIVITY PART OF FIELD EXERCISE? — ☐ a. YES ☐ b. NO

21. WAS THIS PERSON'S ACTIVITY PART OF TACTICAL TRAINING? — ☐ a. YES ☐ b. NO

22. OPERATIONAL CATEGORY (Identify operations category that best describes the overall mission at time of accident.)

23. SEVERITY OF INJURY TO THIS PERSON (Check one only) — ☐ a. FATAL ☐ b. PERMANENT TOTAL DISABILITY ☐ c. PERMANENT PARTIAL DISABILITY ☐ d. LOST WORKDAY CASE - DAYS AWAY FROM WORK ☐ e. LOST WORKDAY CASE - RESTRICTED WORK ACTIVITY ☐ f. NONFATAL CASE WITHOUT LOST WORKDAYS ☐ g. FIRST AID ONLY ☐ h. NO INJURY ☐ i. MISSING AND PRESUMED DEAD

24. WORKDAYS LOST (Estimate)

25. WORKDAYS RESTRICTED (Estimate)

26. TYPE/NATURE OF INJURY/OCCUPATIONAL ILLNESS

27. BODY PART AFFECTED

28. CAUSE OF INJURY/OCCUPATIONAL ILLNESS

29. VEHICLE RESTRAINT SYSTEM — ☐ a. USED ☐ b. NOT AVAILABLE ☐ c. NOT APPLICABLE ☐ d. AVAILABLE BUT NOT USED

30. THIS PERSON'S ERRORS WHICH CAUSED OR CONTRIBUTED TO THE ACCIDENT (Describe what occurred and the results)

SECTION B — PROPERTY AND/OR MATERIEL INVOLVED

31. LIST ALL PROPERTY INVOLVED IN THE ACCIDENT, WHETHER DAMAGED OR NOT. IF ACCIDENT INVOLVED ARMY OPERATIONS, SHOW COST OF ANY DAMAGE.

NO.	a. NAME OF ITEM (Complete nomenclature, i.e., name, mfr, model)	b.	OWNERSHIP	c.	AMOUNT OF DAMAGE
1					
2					
3					

32. MATERIEL FAILURE(S)/MALFUNCTION(S) WHICH CAUSED OR CONTRIBUTED TO THE ACCIDENT (Tell what caused and type of failure)

33. CONTROL NUMBER FOR THE SIR COVERING EACH FAILURE/MALFUNCTION (Block 3 of SF 368)

SECTION C — ENVIRONMENTAL CONDITIONS INVOLVED

34. ENVIRONMENTAL CONDITION(S) WHICH CAUSED OR CONTRIBUTED TO THE ACCIDENT

SECTION D — DESCRIPTION AND CORRECTIVE ACTION

35. FULLY DESCRIBE THE ACCIDENT (Where recognized as critical on block 31, tell how recognized participants are trained to do it.)

36. ACTION TAKEN, ANTICIPATED, OR RECOMMENDED TO CORRECT THE CAUSE(S) OF THIS ACCIDENT

37. SIGNATURE OF COMMAND REPRESENTATIVE

38. COMMAND REVIEW — a. b. c.

SAFETY STAFF USE ONLY

39. REPORT SUBMISSION — ☐ a. INITIAL ☐ b. CHANGE

40. MACOM

41. LOCAL REPORT NUMBER

42. ACCIDENT TYPE

43. TYPE OF VEHICLE COLLISION

44. SAFETY STAFF POINT OF CONTACT (Include grade/rank, name and phone)

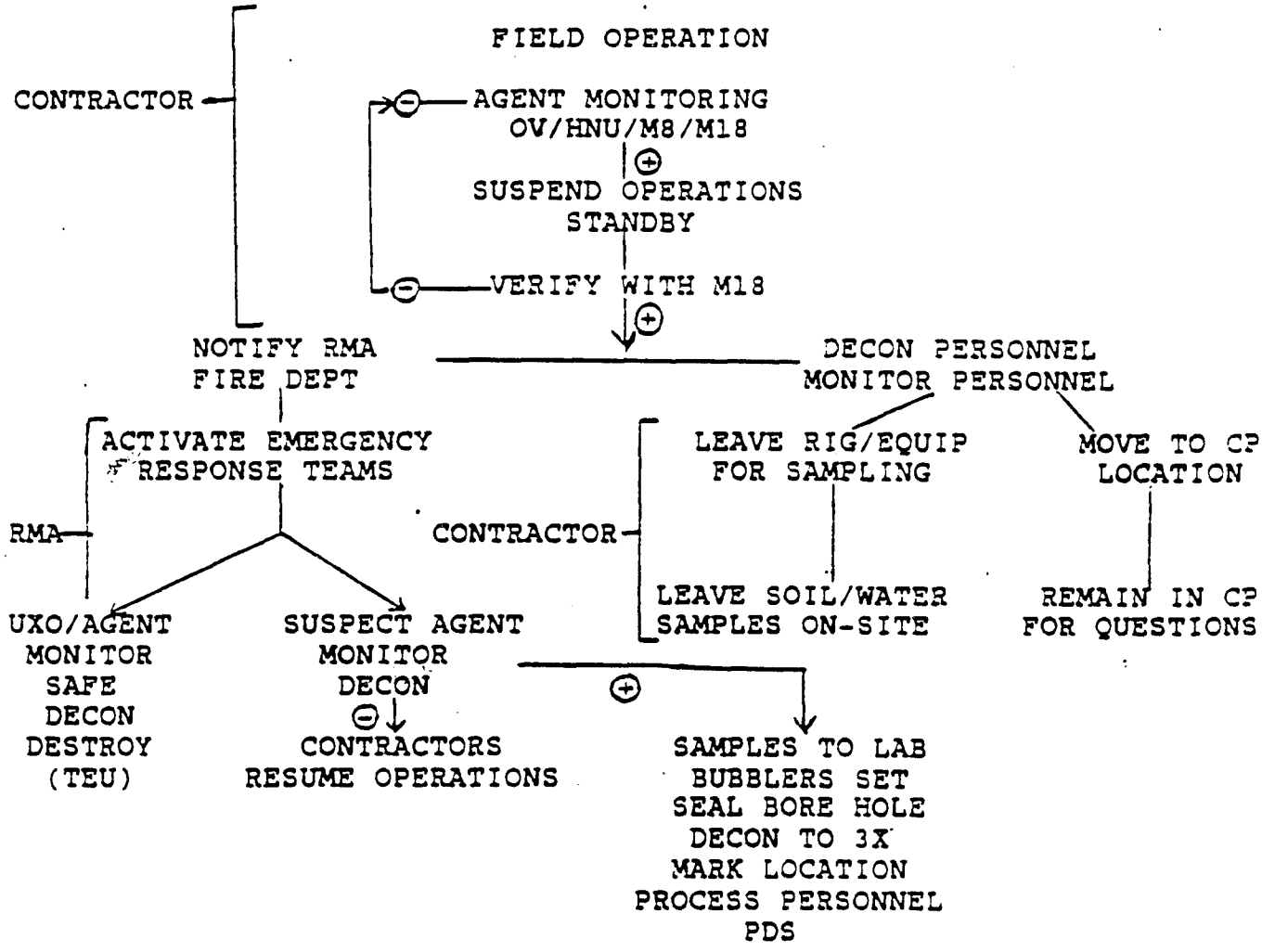
45. SPECIAL REQUIREMENTS

46. DATE REPORT COMPLETED (YY-MM-DD)

DA FORM [illegible] 285 EDITION OF 1 JAN 71 IS OBSOLETE

FIGURE 5

FIELD ACTIONS TAKEN FOR DETECTION OF CHEMICAL AGENTS



APPENDIX B

DEPARTMENT OF THE ARMY
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO 80022-2180

REPLY TO
ATTENTION OF:

SMCRM-SF 18 May 1988

SUBJECT: Command Policy Letter: Control of Suspected Munitions or Other Hazardous Material Found on Post

SEE DISTRIBUTION

1. All potentially hazardous munitions, munition components, and sensitive or hazardous materials will be controlled from the time of discovery on the Installation until their final disposition. Accountability will be maintained by the Director of Installation Services. Quantities issued to other activities will be controlled by the appropriate responsible officer, who will maintain adequate records to show disposition at all times. All such material will be stored in accordance with current regulations.

2. Any suspected munition or hazardous material found on the Installation will not be moved or handled by the person(s) discovering the suspect item. The location will be noted and the finder's supervisor or foreman will be advised immediately. The following information will be provided:

a. Name of individual discovering item.

b. Location and telephone number of supervisor (foreman) calling.

c. Description of munition or hazardous material found.

d. Specific location of the item(s).

e. Brief description of how the munition or hazardous material was located.

3. Responsibilities:

a. <u>Supervisor</u> (of the individual finding the suspect item) will:

(1) Immediately notify the Chief, Security Office, Extension 367/Fire Prevention Branch, Extension 192, of the finding.

(2) Fill in the initial information (Section A) of the DA Form 3265-R (sample attached) and give to EOD personnel for completion of Section B (or C, Fire Prevention Branch, if EOD is not called in).

This letter supersedes letter, SMCRM-SF, 11 March 1986.

SMCRM-SF 18 May 1988
SUBJECT: Command Policy Letter: Control of Suspected Munitions or Other Hazardous Material Found on Post

b. Chief, Fire Prevention Branch, will:

(1) Make a preliminary inspection, designate/mark the area of the item, and notify the Commander, or his designee, who will make the determination if support from the 94th EOD is necessary. (If Tech Escort Detachment is on post, they will be notified in lieu of the 94th EOD.)

(2) After investigating and verifying the report, immediately notify the Safety Manager of the reported finding.

(3) If munitions or toxic chemicals are involved, notify security for an access control team.

(4) Complete DA Form 3265-R if EOD is not called in. Copies of the report will be forwarded that day to Chief, Supply division; Facilities Engineer; Chief, Quality Assurance; and Director, Contamination Control.

c. Chief, Security Office, will:

(1) Control access onto and off the site.

(2) Provide escort for the EOD team in moving the munition or hazardous material to an appropriate storage location as determined in coordination with the Chief, Supply Division.

(3) Report appropriate items on DA Form 3056 in accordance with the provisions of AR 190-11 and/or AR 190-40.

d. Chief, Supply Division, will:

(1) Research found items to determine if the reported commodity is on record. If not on record, the commodity will be recorded and reported to the appropriate National Inventory control Point (NICP).

(2) Notify the security and Safety Offices immediately for action under Serious Incident Reporting Procedures.

e. Safety Manager will: Incorporate this information in the safety indoctrination given to all new employees.

f. Directors and Office Chiefs will: Ensure that all personnel are informed of the procedures directed in paragraphs 1 and 2 above.

Encl

EDWARD R. ETTNER, JR.
MAJ, CmlC
Commanding

DISTRIBUTION B

EXPLOSIVE ORDNANCE INCIDENT REPORT

For use of this form, see FM 9-15 and 9-16; the proponent agency is U.S. Continental Army Command.

1. UNIT NUMBER	2. CONTROL NUMBER	3. UNUSUAL	4. ROUTINE
SMCRM-		X	

SECTION A: INITIAL INFORMATION

5. DATE/TIME REPORTED	9. INCIDENT LOCATION	11. ITEM(S) REPORTED
10 Jan 86, 0930 hrs	In back of Bldg 109 North side	Green ton container appears to be bent in in the middle
6. REPORTED BY: U. R. Safe		
7. PHONE NUMBER: 289-0001	10. WHO TO CONTACT: Security Police, X-369; Fire Prev Br, X-192	
8. ADDRESS: Rocky Mountain Arsenal		

SECTION B: ACTION BY EOD

12. PERSONNEL DISPATCHED	13. DATE/TIME	14. TRAVEL DATA	15. MAN-HOURS
	A. DPRT	A. AIR-FLYING TIME	A. TRAVEL
	B. ARR	B. VEH-MILEAGE	B. INCIDENT
	C. COMPL		

16. CONFIRMED IDENTIFICATION	17. DISPOSITION

18. INCIDENT NARRATIVE (INCLUDE ALL SIGNIFICANT DETAILS AND PROBLEMS)

19. AUTHENTICATION

A. TYPED NAME, GRADE OF UNIT COMMANDER	B. TELEPHONE NO.	C. DATE

APPENDIX C

EMERGENCY RESPONSE PERSONNEL LIST

ECC Commander	David L. Heim, Ext. 115
RMA Commander	Edward R. Ettner, Jr., MAJ, Ext. 141
Program Manager, Technical Operations	David S. Strang, X 118
Chemical Accident/Incident Response Officer (CAIRO)	Susan Neary, CPT, Ext. 424 (when on post)
Chemical Accident/Incident Response Officer (CAIRO)	Tom James, Ext. 264
Assistant CAIRO (A/CAIRO)	Martin Wittig, 192
Director, Installation Services	David L. Heim, 115
Laboratory	Elijah G. Jones, Ext. 194
Chief, Technical Support Office	Elijah G. Jones, Ext. 194
Quality Assurance	William Moloney, Ext. 112
Monitoring Team	William Moloney, Ext. 112
DIS Monitoring Team	To Be Designated, Ext. 115
Chief, Security Office	William Dowell, Ext. 367
Security Desk	Desk Sergeant, Ext. 369
Safety Manager	Alma T. Harris, Ext. 338
Public Affairs Officer	William R. Thomas, Ext. 441
Contractor On-Site Safety Officer	To Be Designated
Personal Protective Clothing	Thomas James, Ext. 264
Chief, Systems Operation Division	Thomas James, Ext. 264
Hot Line Team	System Operation Personnel, Ext. 351

Emergency Response Personnel List (continued)

Decon Team	TEU/EOD Personnel when on post), Ext. 424
TEU/EOD Project Officer	Susan Neary, CPT, Ext. 424
TEU NCOIC, Aberdeen, MD	AV 584-4383
94th EOD, Fort Carson, CO	AV 691-4242
Surety Officer, AMCCOM, (MAJ Calvin Austin)	AV 793-4815
Alternate Surety Officer, AMCCOM (Betty Peterson)	AV 793-3193

APPENDIX D

INDUSTRIAL CHEMICALS LIST

1. Lead (Pb).

(a) Lead, inorganic lead, includes lead oxides, metallic lead, lead salts, and organic salts, but excludes lead arsenate and organic lead compounds. Lead is a blue-gray metal which is soft and malleable. Lead is slightly soluble in water in the presence of nitrates, ammonium salts and carbon dioxide.

(b) The routes of entry are inhalation and ingestion. Lead can cause anemia and hemopoetic system disturbances, kidney damage, central nervous system damage, and reproductive problems (decreased sperm production and teratogenesis).

(c) Symptoms: Early Effects:

(1) Fatigue.

(2) Sleep disturbance.

(3) Headache.

(4) Nausea.

(5) Aching bones and muscles.

(6) Constipation.

(7) Abdominal pains.

(8) Decreased appetite.

(9) Irritability.

(d) Symptoms: Long Term Effects:

(1) Anemia.

(2) Pallor.

(3) Lead line on gums.

(4) Decreased hand-grip strength.

(5) Wrist or foot drop.

(e) After exposure to lead, irrigate eyes with water.

(f) Flush skin with soap and water.

(g) If exposure is respiratory, move the exposed person to fresh air at once and perform artificial respiration.

(h) If the chemical has been swallowed, give large quantities of water and induce vomiting. WARNING: DO NOT MAKE AN UNCONSCIOUS PERSON VOMIT.

(i) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

2. Mercury (Hg).

(a) Mercury is a silvery, mobile, odorless liquid. It boils at 356 - 357 degrees Centigrade. Its vapor pressure at 20 degrees Centigrade is 0.0012 mmHg.

(b) The routes of exposure are inhalation of mercury vapor, skin absorption, and skin and eye contact. Mercury exposure can cause skin and eye irritation. Mercury exposure can also causepneumonitis and bronchitis. Exposure also can cause central nervous system damage and kidney damage.

(c) Symptoms:

(1) Weakness.

(2) Fatigue.

(3) Loss of appetite.

(4) Insomnia.

(5) Loss of weight.

(6) Indigestion.

(7) Diarrhea.

(8) Metallic taste in mouth.

(9) Increased salivation.

(10) Inflammation of gums.

(11) Black line on gums.

(12) Loosening of teeth.

(13) Irritability.

(14) Loss of memory.

(15) Excitability.

(16) Anxiety.

(17) Delirium w/hallucinations.

(18) Melancholia.

(19) Manic depressive psychosis.

(d) If mercury contacts the eyes, irrigate immediately.

(e) If mercury contacts the skin, wash with soap and water promptly.

(f) If exposure is respiratory, move the exposed person to fresh air at once and perform artificial respiration.

(g) If mercury is swallowed, give large quantities of water and induce vomiting. WARNING: DO NOT MAKE AN UNCONSCIOUS PERSON VOMIT.

(h) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

3. Arsenic (As).

(a) Arsenic is a semi-metallic element. The poisonous, whitish, or steel-grey powder of white oxide of arsenic is insoluble in water. Arsenic is present as an impurity in many metal ores and is generally produced as arsenic trioxide as a by-product in smelting of these ores, particularly copper.

(b) The primary routes of entry into the body are skin absorption and ingestion.

(c) Symptoms:

(1) Conjunctivitis.

(2) Visual disturbances.

(3) Peripheral neuropathy (loss of feeling in extremities).

(4) Hyperpigmentations of the skin (increased discoloration).

(5) Palmer and plantar (skin of the hands) hyper-pigmentation of the skin.

(6) Palmer and plantar hyperkeratosis (thicker callouses on hands).

(7) Dermatitis.

(8) Skin cancer.

(d) After exposure to arsenic, irrigate eyes with water.

(e) Wash contaminated areas of the body with soap and water.

(f) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

4. Dibromochloropropane (DBCP).

(a) DBCP is an amber to brown liquid with a pungent odor. It boils at 199 degrees Centigrade under a pressure of 760 mmHg. DBCP has been supplied to the agricultural industry since 1955 in the form of liquid concentrate, emulsifiable concentrate, powder, granules, and solid material.

(b) NIOSH recommends that exposure be limited to no greater than 10 parts per billion as a TWA concentration for 10 hour work-shifts for a forty-hour week.

(c) The primary route of entry into the body is inhalation of vapors.

(d) Ingestion may result in forms of cancer, but cancer has not been proven to be caused by inhalation of DBCP vapors. Target organs of DBCP exposure include the kidneys, liver, and reproductive system.

(e) Symptoms: Chronic Exposure:

(1) Sterility.

(2) Diminished renal functions.

(3) Degeneration and cirrhosis of the liver.

(f) After inhalation of DBCP vapors, move the exposed person into fresh air at once.

(g) After ingestion of DBCP, give large quantities of water and induce vomiting. WARNING: DO NOT MAKE AN UNCONSCIOUS PERSON VOMIT.

(h) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

5. Chlorinated Pesticides (e.g., Dieldrin and Aldrin).

(a) Chlorinated Pesticides are colorless to light-tan solids with a mild chemical odor, melting at from 175 degrees to 176 degrees Centigrade. These are man-made compounds belonging to the group of cyclodiene insecticides and a subgroup of the chlorinated cyclic hydrocarbine insecticides, including DDT, BHC, etc.

(b) These chemicals are persistent in the environment due to low volatility and low solubility in water. They are extremely apolar, resulting in a high affinity for fat leading to a progressive accumulation in the food chain.

(c) The Federal limit of exposure in 0.25 mg/m3. The STEL value is 0.75 mg/m3, and the IDLH level is 450 mg/m3.

(d) The main routes of entry into the body include inhalation, ingestion, skin absorption, eye and skin contact. The target organs are the central nervous system, liver, kidney, and skin.

(e) Symptoms:

(1) Headaches.

(2) Dizziness.

(3) Nausea.

(4) Vomiting.

(5) Malaise.

(6) Sweating.

(7) Myclonic limjerks (voluntary muscle twitching).

(8) Clonic or tonic convulsions (involuntary muscle).

(9) Coma.

(f) After exposure to chlorinated pesticides, irrigate eyes immediately with water.

(g) Wash skin with soap and water promptly.

(h) If the exposure is respiratory, move the casualty into fresh air at once and perform artificial respiration.

(i) If exposure is by ingestion, give large amounts of water and induce vomiting. WARNING: DO NOT MAKE AN UNCONSCIOUS PERSON VOMIT.

(j) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

6. Benzene (C_6H_6).

(a) Benzene is a clear, volatile, colorless, highly flammable liquid with a characteristic odor. It is used as a constituent in motor fuels, as a solvent, as a chemical intermediate, and in the manufacture of detergents and explosives.

(b) Benzene enters the body by inhalation of vapors, through cuts, ingestion, and eye contact. Entry through intact skin is possible, but is less direct. Benzene attacks the blood, central nervous system, skin, bone marrow, eyes, and the respiratory system.

(c) Symptoms: Local:

(1) Irritation of skin, eyes, and upper respiratory tract.

(2) Pulmonary edema and hemorrhage.

(3) Dry scaly dermatitis.

(d) Symptoms: Systemic:

(1) Central nervous system depression.

(2) Anemia.

(3) Hypo- or hyperactive bone marrow (increase or decrease in red blood cell production).

(4) Leukemia.

(5) Chromosomal aberrations.

(e) After exposure to Benzene, irrigate the eyes immediately with water.

(f) Wash skin with soap and water promptly.

(g) If exposure is respiratory, move the casualty into fresh air at once and perform artificial respiration.

(h) If exposure is by ingestion, get medical attention. WARNING: DO NOT INDUCE VOMITING.

(i) Transport the casualty immediately to the FAMC ER. Notify the ER of the incoming casualty.

7. Unexploded Ordnance (UXO).

(a) The operational area may contain UXOs filled with high explosives and/or chemical agents.

(b) UXOs will be disposed of only by qualified EOD personnel IAW paragraph 7f, SOP TEU-RMA 50-11.

ATTACHMENT 3

RESPIRATOR, INSPECTION, CLEANING, MAINTENANCE, AND STORAGE

RESPONSES TO SHELL OIL COMPANY COMMENTS ON THE DRAFT TASK PLAN FOR RMA ABANDONED WELL CLOSURE PROGRAM DECEMBER 1988

Shell Oil Company submitted a letter stating that they had no comments on the Draft Task Plan.

RESPONSES TO COMMENTS ON
THE DRAFT FINAL (VERSION 2.0) OF TABLE 2.2
OF THE DRAFT FINAL TASK PLAN FOR THE
ABANDONED WELL CLOSURE PROGRAM

State of Colorado Comment: At this time, the State is not proposing to delete any of the wells from this program (i.e, save for present or future programs).

Response: *Comment was noted.*

Shell Oil Comment: List of wells which Shell believes should be retained for monitoring.

SECTION 1

Well Number
01051
01052
01053
01054
01055
01056

Remarks
These wells can be used to monitor and evaluate the cleanup of the Hydrazine plant and vicinity. In addition, they provide control in the northeastern part of Section 1.

SECTION 19

Well Number
19003
19005
19006
19007
19011*

Remarks
These wells are located in an area currently having very few monitoring points and are completed in the Upper Denver Formation. They can be used for water level measurements and control on water quality.

*Well 19011 is completed about 47 feet into the Denver Formation. The well was sampled only in 1978 and 1979. The analysis indicated a concentration f DCPD of 89.7 ug/l in 1978. Resampled in 1979 which results of less than 10 ug/l. Prior to closure, this well should be resampled for DCPD.

SECTIONS 27 AND 28

Well Number

27040	28007
27041	28008
27043	28009
27044	28011
27051	28012
28002	28013
28003	28014
28004	28018
28005	

Remarks

These are alluvial wells and therefore would not provide vertical pathways for contaminant movement. Historically, some of the wells have shown groundwater contamination. These wells should be retained until final remediation plans are implemented.

SECTION 36

Well Number

36001	36087
36017	36088
36019	36089
36054	36093
36080	

Remarks

These are alluvial wells or composite wells which are completed in alluvium and the uppermost Denver Formation. Many wells in Section 36 are approved for closure; many others are being considered for closure. The wells listed should be retained to provide an adequate network to monitor groundwater quality in the western half of Section 36.

Response: *Comment noted, wells have been removed from list.*

R.L. Stollar Comment: The CMP team has reviewed a list of wells "Approved for Closure" under the Well Abandonment Program (IRA-3). This list includes wells that are currently monitored under the CMP. After reviewing this list and considering comments made by Mr. Anderson, we recommend <u>not</u> closing the following 11 wells at this time:

25004, 25007, 26051, 26056, 26057, 26058, 26060, 26064, 27037, 34001, and 35005.

Response: *Wells 25004, 25007, 26051, 26056, 26057, 26058, 26060, 26064 have been removed from the "Approved for Closure List". Well 27037 was not on the "Approved for Closure List". Wells 34001 and 35005 which had previously been approved for closure have already been closed.*

R.L. Stollar Comment: We recommend abandoning the following six wells: 22002, 26052, 26053, 26054, 26126, and 36047.

Response: *These wells are included on the "Approved for Closure List".*

R.L. Stollar Comment: There were another nine CMP monitoring wells listing in the "Approved for Closure List" which have already been closed under former Task 37. They are wells 23034, 23054, 24050, 24120, 26043, 26044, 26046, 33016, and 35024. Mr. Anderson also approved closure of well 27037, which is not included on this list.

Response: *All of the wells closed under Task 37 are so identified on Table 2-2.*

R.L. Stollar Comment: We also recommend that 99 CMP monitoring wells listed under the "Considered for Closure" column be removed from the list at this time. We recommend that they not be considered for closure until further assessment can be made and/or suitable replacement wells be installed. These wells are listed below.

01010	01012	01014
01015	01020	01055
01061	02004	19002
19003	19005	19006
19007	19011	23053
23055	23144	23146
23150	23151	23160
24183	24188	26023
26024	26025	26026
26027	26028	26029
26048	26049	26050
26055	26061	26063
26096	26123	26124
27040	27041	27042
27043	27044	27045
27049	27051	28002
28003	28006	28008
28012	28020	28014
28018	28021	28022
30002	31002	35007
35008	35009	35012
35013	35014	35015
35016	35018	35020
35021	35030	35048
36001	36010	36013
36017	36024	36029
36036	36043	36050
36056	36057	36061
36062	36068	36072

36062	36068	36072
36073	36086	36087
36089	36090	36092
36093	36094	36099
36104	36105	36110

Response: *These 99 CMP monitoring wells have been removed from the "Considered for Closure List. All remaining wells which were previously on the "Considered for Closure List" have been moved onto the "Approved for Closure List".*

ATTACHMENT 4

WORK LOCATION PERSONNEL PROTECTION AND SAFETY EVALUATION FORM

WESTON

WORK LOCATION PERSONNEL PROTECTION AND SAFETY EVALUATION FORM

Attach Pertinent Documents/Data

Fill in Blanks As Appropriate

WO # 2281-10-01

Division Econ

Office Denver

Prepared by W. Somers

Date 10/25/88

Reviewed by

Date

Approved by

Date

A. Work Location Description

1. Name Rocky Mountain Arsenal

2. Location Commerce City, Colorado Adams County

3. Type: HW Site (X) Industrial (X)
Spill ( ) Construction ( )
(X) Existing WESTON Work Location
(X) Existing Client Work Location
Other ( ) Describe

4. Status

5. Anticipated activities: Field search for location of monitoring and agricultural wells. Abandonment of wells.

6. Size Approximately 32 square miles

7. Surrounding Population Residential/Industrial to West; Agricultural to E N

8. Buildings/Homes/Industry

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9. Topography Relatively flat prairie

(summe

10. Anticipated Weather Cold, snow (winter); Hot,dry, occasional T-storms

11. Unusual Features None

12. Site History Since 1942 has been used for the production of chemical munitions and pesticides.

B. Hazard Description

1. Background Review: Complete (X) Partial ( )

If partial, why?

2. Hazard Level: A ( ) B (X)

Unknown ( ) C (X) D (X)

Justification D- for well search (non-intrusive), Level of protection dependent upon hazard at each well location.

3. Types of Hazards: (Attach additional sheets as necessary)

A. Chemical (X) Inhalation (X) Explosive (X)

Biological ( ) Ingestion (X) O_2 Def. ( )

Skin Contact (X) Toxic ( )

Describe The chemical agents at the site present an inhalation, ingestion, contact

B. Physical (X) Cold Stress (X) Noise (X)

Heat Stress (X) Other ( )

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Describe Noise from drill rigs, work will be performed in winter and summer

C. Radiation ( )

Describe

4. Nature of Hazards:

Air (X) Describe Contaminants in the ground water may volatilize and create an air hazard during well closure activities.

Soil ( ) Describe

Surface Water ( ) Describe

Groundwater (X) Describe Monitoring data from the area of the disposal basin indicates significant contamination.

Other ( ) Describe

). Chemical Contaminants of Concern ( ) N/A

Contaminant	TLV (PPM)	I.D.L.H. (PPM)	Source/Quantity Characteristics	Route of Exposure	Symptoms of Acute Exposure	Instruments Used to Monitor Contaminant
Aldrin	0.25 mg/m^3	Ca	Groundwater contamination	Inhalation, Absorbtion, Ingestion, Contact	Headache, dizziness, nausea, vomiting, myoclouic jerks	
Dieldrin	0.25 mg/m^3	Ca	"	"	"	
Endrin	0.1 mg/m^3	200 mg/m^3	"	"	Epileptiform convuls, stupor, headache, dizz.	
Chloroform	10	Ca	"	Inhalation, Contact	Dizz., mental dullness, nausea, headache	OVA
Carbon tetrachloride	5	Ca	"	"	CNS depression, nausea, vomit, skin irritant	HNu, OVA
Chlorobenzene	75	2400	"	Inhalation, ingestion, Contact	Irritant skin, eyes, nose, drowsiness	
Benzene	5	Ca	"	Inhalation, Absorbtion, Ingestion, Contact	Irritant eyes, nose, gidiness, headache, nausea, staggered gait	HNU, OVA
Ethylbenzene	100	2000	"	Inh., Ing., Contact	Irritant eyes, mucous membranes, headache	HNU, OVA
DDT	1 mg/m^3	Ca	"	Inh., Abs., Ing., Contact	Paresthesia tongue, lips, face; tremor, apprehension, dizziness	
1,1-Dichloroethane	100	4000	"	Inh, Ing., Contact	CNS depression; skin irritant drowsiness	OVA
1,2-Dichloroethane			"			OVA
1,1-Dichloroethene			"			OVA
1,2-Dichloroethene	200	4000	"	Inh., Ing., Contact	Irritant eyes, resp. system, CNS depression	OVA
T-1,2-Dichloroethene			"			
Methylene Chloride	100	5000	"	Inh., Ing., Contact	Fatigue, weakness, sleep, Litehead; limbs numb, tingle	HNu, OVA
3435A Toluene	100	2000	"	Inh, ing, abs, Contact	Fatigue, weakness, confusion, euphoria, dizz; headache;	HNu, OVA

Contaminant	TLV (PPM)	I.D.L.H. (PPM)	Source/Quantity Characteristics	Route of Exposure	Acute Exposure	Contaminant
Trichloroethene	25	Ca	Groundwater	Inh, Ing, Contact	Headache, vertigo, Visual distortion, tremors	HNU, OVA
1,1,1-Trichloroethane			"			OVA
1,1,2-Trichloroethane	10	Ca	"	Inh, Ing, Abs, Contact	Irritant nose, eyes; CNS depression	HNU, OVA
Tetrachloroethene	50	Ca	"	Inh, Ing, Contact	Irritant eyes, nose, throat; nausea; flush face, neck	HNu, OVA
Dicyclopentadiene (DCPD)	5		"			
Dibromochloropropane (DBCP)	.001	Ca	"	Inh, abs, Contact	Drowsiness, nausea, vomit; irritant eyes, nose, throat	
Diispropylmethyl Phosphonate (DIMP)						
Hydraline	11	Ca	"	Inh, Abs, Ing, Contact	Irritant eyes, nose, throat; temp blindness, dizziness, nausea	
Nitrosodimethylamine	Ca	Ca	"	Inh, Abs, Ing, Contact	Nausea, vomit, diarrhea, abdominal cramps, headache	
Lead	0.05mg/m^3	--	"	Inh, Ing, Cont	Lassitude, insomnia, anorexia	
Mercury	0.05mg/m^3	28mg/m^3	"	Inh, Ing, Cont	Cough, Dysp , Bronchitis, pneumonia; tremor; insomnia; indecision	Hg Monitor
Cadmium	0.05mg/m^3	40mg/m^3 Ca	"	Inh, Ing	Pulm edema, dysp, cough, tight chest, headache	
Zinc	1mg/m^3	2000mg/m^3	"	Inh, Contact	Irritant nose, throat; cough, copius sputum	

6. Physical Hazards of Concern ( ) N/A

Hazard	Description	Location	Procedures Used to Monitor Hazard
Overhead	Operations around drill rig	during well abandonment	Wear hard hat Be aware of hazard
Entanglement	Loose clothing caught in drill rig	"	No loose clothing allowed at site, long hair under hard hat
Flying debris	Steam cleaning	Decon pad	Wear eye protection Face shield or goggles

7. Work Location Instrument Readings ( ) N/A

Location_____

% O_2_____ % LEL_____

Radioactivity_____ PID_____

FID_____ Other_____

Other_____ Other_____

Location_____

% O_2_____ % LEL_____

Radioactivity_____ PID_____

FID_____ Other_____

Other_____ Other_____

Location_____

% O_2_____ % LEL_____

Radioactivity_____ PID_____

FID_____ Other_____

Other_____ Other_____

Location_____

% O_2_____ % LEL_____

Radioactivity_____ PID_____

FID_____ Other_____

Other_____ Other_____

8. Hazards expected in preparation for work assignment. ( ) N/A

Describe: Locating the drill rig on the well to be abandoned.

Personnel Protective Equipment

1. Level of Protection

A ( ) B ( ) C ( ) D (X) Location/Activity:

Well search

A ( ) B (X) C (X) D (X) Location/Activity:

Well abandonment based on potential contamination . Background in breathing zone =D, Bkg to 5 units = C, 5-50 units = level 15

2. Protective Equipment (specify probable quantity required)

Respiratory ( ) N/A

(X) SCBA, Airline

(x) Full Face Respirator (Cart._____)

(x) Escape Mask

( ) None

( ) Other_____

( ) Other_____

Clothing ( ) N/A

( ) Fully Encapsulating Suit

( ) Chemically Resistant Splash Suit

( ) Apron, Specify_____

(X) Tyvek Coverall

(X) Saranex Coverall

( ) Coverall, Specify_____

( ) Other_____

( ) Other_____

Head & Eye ( ) N/A

(x) Hard Hat

(x) Goggles

(x) Face Shield

( ) Chemical Eyeglasses

( ) None

( ) Other_____

Hand Protection ( ) N/A

(X) Undergloves Latex (Type)

(X) Gloves Nitril (Type)

(X) Overgloves Butyl (Type)

( ) None

( ) Other_____

Foot Protection ( ) N/A

(X) Safety Boots

(X) Disposable Overboots

( ) Other_____

_____

3. Monitoring Equipment ( ) N/A

(X) CGI

(X) O_2 Meter

( ) Rad Survey

( ) Detector Tubes

Type:_____

_____

_____

(X) PID

(X) FID

( ) Other_____

_____

( ) Other_____

_____

). Personnel Decontamination (Attach Diagram)

Required (X) Not Required ( )

Equipment Decontamination (Attach Diagram)

Required (X) Not Required ( )

If required, describe and list equipment Drill rig will be decontaminated using steam cleaner. Equipment for determining well depth will be decontaminated using trisodium phosphate, alconex and water solution and rinsing with tap water.

E. Personnel

NAME	WORK LOCATION TITLE/TASK	MEDICAL CURRENT	FIT TEST CURRENT	CERTIFICATION LEVEL
2.		( )	( )	( )
1.		( )	( )	( )
3.		( )	( )	( )
4.		( )	( )	( )
1.		( )	( )	( )
5.		( )	( )	( )
7.		( )	( )	( )
8.		( )	( )	( )
9.		( )	( )	( )
1.		( )	( )	( )

Site Safety Coordinator_____

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F. Activities Covered Under this Plan

Task No.	Description	Preliminary Schedule
1	Search and location of wells to be abandoned	Nov 15, 1988 - Nov., 1989
2	Abandon wells	Nov, 1988 - Nov., 1989

G. Subcontractor Management

Name and Address of Subcontractor: _____

_____

Activities to be Conducted by Subcontractor: _____

_____

EVALUATION CRITERIA

Item	Adequate	Inadequate	Comments
Medical Surveillance Program	( )	( )	_____
Personal Protective Equipment Availability	( )	( )	_____
On-Site Monitoring Equipment Availability	( )	( )	_____
Safe Working Procedures Specification	( )	( )	_____
Training Protocols	( )	( )	_____
Ancillary Support Procedures (if needed)	( )	( )	_____
Emergency Procedures	( )	( )	_____
Evacuation Procedures Contingency Plan	( )	( )	_____
Decontamination Procedures Equipment	( )	( )	_____
Decontamination Procedures Personnel	( )	( )	_____

GENERAL HEALTH AND SAFETY PROGRAM EVALUATION: ADEQUATE ( ) INADEQUATE ( )

ADDITIONAL COMMENTS: _____

_____

EVALUATION CONDUCTED BY: _____ DATE: _____

H. Contingency Contacts

Agency	Contact	Phone Number
Fire Department	On-site	(303) 289-0187
Police Department	Post security	(303) 289-0369
Health Department	Colo. Dept. of Health	(303) 320-8333
Poison Control Center	Denver & Vicinity	(303) 629-1123
State Environmental Agency	Health Department	(303) 320-8333
EPA-Regional Office		
EPA-ERT. ICOM		
Spill Contractor		
State Police	Colo. State Patrol	(303) 757-9475
F.A.A.	Local Coordinator	(303) 340-5525
Civil Defense	Emergency Services	(303) 279-2511
On Site Coordinator	B. Trautmann	(303) 289-0335
Site Telephone	To be provided	
Nearest Telephone	(Location)	
Other		

I. Contingency Plans

Spill, Accidental Release; Describe The post emergency procedures will be used. Fire and security will be notified; procedure attached.

Fire Explosion; Describe

Other; Describe

Exit Routes, Communication Systems; Describe

MEDICAL EMERGENCY

Name of Hospital Aurora Presbyterian

Address: 700 Potomac Street, Aurora Phone No. (303) 363-7200

Name of Contact

Address: Phone No.

Route to Hospital: (Attach Map) Quebec Street south to I-70. I-70 east to I-225. I-225 south to 6th Avenue. Exit 6th Avenue west to Potomac Street. Potomac north to AMI Aurora Presbyterian.

Travel Time From Site (Minutes) 20

Distance to Hospital (Miles) 15

Name/Number of 24 Hr. Ambulance Service On-site, Fire Department with paramedics.

HEALTH AND SAFETY PLAN
APPROVAL/SIGN OFF FORMAT

I have read, understood, and agreed with the information set forth in this Health and Safety Plan (and attachments) and discussed in the Personnel Health and Safety briefing.

Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Site Safety Co-ordinator	Signature	Date
George Crawford Director, Corporate Health and Safety	Signature	Date
Mark Hutson Project Manager	Signature	Date
William P. Lynott Project Director/ Department Manager	Signature	Date

Personnel Health and Safety Briefing Conducted By:

Name	Signature	Date

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ATTACHMENT 5

FIRST AID GUIDE

WESTON

FIRST-AID GUIDE

Anyone who attempts to administer first aid to an injured person should remember that such treatment is only emergency care to be administered until professional medical aid can be obtained.

The primary rule to follow in all injury cases is to keep calm. In addition, follow these instructions:

- Send for help.
- Do not move an injured person until it is certain that he/she can be moved safely.
- Keep the patient quiet and warm.
- Maintain vital life functions (breathing and circulation).
- Observe and treat for shock.
- Identify the offending agent or poison, if possible.
- Do not give liquids to an unconscious person.
- Do not act without thinking; doing the right thing is more important than doing things in a hurry.

Report every injury, including minor cuts, scratches, bruises, burns, etc., to the employee's immediate supervisor. Employees injured in connection with their work should be seen immediately by the supervisor and, if necessary, be sent to a physician or hospital.

E.1 FIRST-AID KITS

An approved first-aid kit is available in the environmental laboratory, and an additional kit will accompany each field team while working on-site.

E.2 TRANSPORTING THE INJURED

Improper transportation increases the possibility of further damage to a severely injured or ill person. Most communities are served by experienced rescue squads or emergency units staffed with trained emergency medical technicians. As circumstances warrant, help may also be requested from local physicians, hospital emergency departments, or poison control centers. Generally, in an emergency, the best course of action is to request help from the community emergency or rescue squad. Its communication system is usually linked to local hospitals, poison control centers, etc. Its transport capability is much safer than, for example, that of a private vehicle hurriedly and improperly rushing a victim to a local hospital.

E.3 RESUSCITATION

All employees can and should become proficient in approved methods of resuscitation. Instruction will be given according to the needs of the employee.

E.4 ARTIFICIAL RESPIRATION

Several techniques for administering artificial respiration include the mouth-to-mouth (mouth-to-nose) and the chest-lift methods. The American Red Cross publishes the most complete instructions for artificial respiration; the Red Cross First Aid Manual is available for reference through the Health and Safety Committee, which will also provide appropriate training for those individuals interested in becoming proficient in the techniques.

E.5 MECHANICAL RESPIRATORS

The inhalator, the respirator, and similar motorless devices are aids only and should not take the place of the approved, manually applied, prone (face down) pressure methods of artificial respiration. Only a trained person should attempt to use this type of equipment.

E.6 ASPHYXIATION

.6.1 Symptoms

The usual symptoms of asphyxiation are yawning, headache, dizziness, nausea, ringing in the ears, and, later, a throbbing of the heart. The symptoms, however, may come on so suddenly that the victim is unaware of any trouble until his/her knees give way and, though conscious, the victim has lost all strength to either walk or crawl. The skin of an asphyxiated person may also change color to blue or cherry red (as may be seen during carbon monoxide poisoning).

E.6.2 Care

Ventilate the lungs with oxygen using the prone method of resuscitation and oxygen supplied with an inhalator. Treat the victim for shock. Never walk an asphyxiation victim; walking quickly uses up the remaining oxygen in the blood.

E.7 TRAUMATIC SHOCK

Any injured person is potentially in shock and should be regarded as such, whether symptoms are present or not.

E.7.1 Symptoms

The degree of shock (circulatory collapse) may be anything from mild to severe; the latter frequently results in death. In cases of mild shock lasting only a short time, the recuperative body processes alone may be successful, and the victim may recover without additional help. Where an injury of a more serious nature has been received, the shock may be delayed and much more severe; symptoms of shock may appear several hours after serious injury. For example, the pulse may become so weak that it is difficult to count; the blood pressure becomes much lower than normal. Nausea and vomiting often occur. The skin of the victim's face and extremities becomes cold and moist and turns pale. Breathing is shallow and rapid and later becomes irregular. Finally, the victim lapses into unconsciousness. By the time these symptoms appear, the person's condition has become serious and life threatening.

E.7.2 Care

Do not move the patient more than is necessary. Loosen tight clothing. Lower patient's head relative to the legs. Do not give alcohol or other stimulants. Keep warm with blankets. Administer oxygen, if necessary.

E.8 BLEEDING

Bleeding after injury may be of three general types: (1) The severing of an artery produces spurting bright-red blood. If the bleeding is not controlled quickly, death can follow in minutes. (2) If a vein is cut, darker colored bleeding occurs in a rather steady flow. (3) If the skin is scraped, burned, or scratched, the smallest blood vessels are damaged. From these capillaries, blood oozes in rather small quantities.

Bleeding can be controlled by one or more of the following methods:

- Elevating the wounded arm or leg.
- Applying direct pressure over the wound with the fingers or a firm bandage.
- Applying pressure on the pressure points.
- Using a tourniquet, but only as a last resort.

E.9 FRACTURES

If you suspect a fracture, call for a physician immediately.

E.9.1 Symptoms

Sudden pain, swelling, and/or physical deformity are the usual symptoms of fractures.

E.9.2 Care

Avoid handling the injured part; do not attempt to set the fractured bone. Immobilize the injured area, and keep the victim in a prone position. Do not move the victim unless absolutely necessary. Treat him/her for shock.

E.10 EYE INJURIES

E.10.1 Foreign Bodies

If a foreign body is on the eyelid, remove it gently with a clean handkerchief. Never rub your eye if a foreign substance is on the pupil. Do not attempt to remove the object, but see a doctor.

E.10.2 Chemicals

Holding the lids apart, wash the eye for 15 minutes with running water at an eye fountain or with a gentle stream of water from a hose or tap. Do not use chemical antidotes. See a doctor immediately.

E.11 CHOKING

Foreign bodies or large pieces of food are the most common causes of choking. When someone has been eating and is suddenly unable to speak or cough, suspect airway obstruction. Clutching the throat is a distress signal.

Three ways to dislodge objects obstructing the air passage are back blows, manual thrust (abdominal thrust or chest thrust), and finger probes. Instructions in these techniques have been prepared by the American Red Cross and are available from the Health and Safety Committee. Remember, back blows and manual thrusts may injure internal organs. Use judgment and care with these techniques.

E.12 FROSTBITE

E.12.1 Symptoms

The symptoms of frostbite are pain and a grayish-white color in the exposed part.

E.12.2 Care

Cover the frozen part with your hand or a dressing, or place it in warm water, so that thawing will occur gradually. Do not rub, expose it to a stove or fire, or put it in hot water; any of these treatments may cause serious permanent damage.

E.13 HEAT EXHAUSTION

E.13.1 Symptoms

A pale face, wet and clammy skin, weak pulse, and below-normal temperature are usual symptoms of heat exhaustion. The victim is usually conscious.

E.13.2 Care

Keep the victim in a prone position with the head low. Wrap him/her in blankets. Give the victim salt water (a teaspoon of salt to a pint of water) to drink in small amounts of frequent intervals and, as a stimulant, a cup of strong coffee or tea or one teaspoon of aromatic spirits of ammonia well diluted in water. If his/her condition does not improve quickly, call a doctor.

E.14 POISON IVY, OAK, AND SUMAC

The best cure for infection from poisonous plants is prevention. Recognize and avoid these plants. Do not burn poisonous plants; the smoke carries the sap, which causes infection on skin contact.

Since the poisonous serum is an acid, an alkali soap similar to yellow laundry soap is recommended for washing. Lather and wash all infected parts as soon after contact as possible; however, avoid scrubbing. Apply a liberal application of calamine lotion to all areas. If the infection is severe, see a doctor.

E.15 SUNSTROKE

E.15.1 Symptoms

Headache, hot and dry skin, red face, high fever, strong pulse, and unconsciousness accompany sunstroke.

E.15.2 Care

Keep the victim in a recumbent position with the head elevated. Apply cold cloths to his/her body to cool it. Always call a doctor.

E.16 COMMON MEDICAL EMERGENCIES

E.16.1 Animal Bites

Wash wounds freely with water, holding them under running tap-water for several minutes if possible. Apply a sterile gauze compress, and be sure to see a doctor immediately.

E.16.2 Punctures and Lacerations

Apply pressure with sterile gauze until bleeding stops; then apply soap and water. Allow the wound to dry and cover it with a sterile gauze dressing.

E.16.3 Bruises

Apply ice bags or cold cloths for about 25 minutes. If the skin is broken, treat the same as for minor lacerations.

E.16.4 Fainting

Keep victim's head slightly lowered. Loosen tight clothing. Pass a crushed aromatic spirits of ammonia inhaler under the victim's nose and sprinkle his/her face lightly with water. If the victim does not respond within a short time, summon a doctor at once and keep the victim warm until the doctor's arrival.

E.16.5 Splinters and Other Foreign Bodies

Apply antiseptic where the sliver is imbedded. If the sliver is small, remove it with tweezers. Care, following removal, is the same for minor cuts. For larger splinters with deep penetration, see a doctor.

E.16.6 Insect Bites

Remove the stinger if it is present. Apply a paste made of baking soda, cold cream, and water. If swelling is pronounced, use an ice bag or cold cloths over the paste.

Remove ticks with tissues and tweezers. Grasp the tick close to its head and remove with slow, firm tug. Do not twist. Alcohol will sometimes make ticks release their bite. Smother them with alcohol on a cotton ball.

E.16.7 Burns

Chemical Burns

Wash with copious amounts of water. Cover burned area loosely with a sterile or clean dry cloth or gauze dressing. Observe for symptoms of shock and treat accordingly. Consult a physician.

Thermal Burns

Remove all easily removable clothing, rings, and jewelry. Wrap burned area in sterile or clean sheets or dry dressings; do not apply creams or ointments. Observe and treat for shock; give oxygen. Give nothing by mouth. Consult a physician.

E.16.8 Scrapes or Abrasions

If the area is dirty, sponge it off gently with wet gauze, blot it dry, and apply an antiseptic to the scraped area. Allow it to dry and apply a dressing if necessary. If the scrape is deep and dirty, see a doctor.

E.16.9 Sprains (Joint Injuries)

Elevate the injured part and apply ice bags or cold cloths for 25 minutes immediately after the accident. If the swelling is pronounced, do not attempt to use the injured part until it is seen by a doctor.

E.17 POISONING

E.17.1 Inhaled Agents

Carry the victim to fresh air immediately; loosen tight clothing. Give artificial respiration by direct inflation if respiration is depressed.

Administer oxygen to assist breathing. Conserve body warmth by wrapping patient in blankets, if necessary.

E.17.2 Ingested (Swallowed) Poisons

Do not attempt any treatment if the patient is convulsing or unconscious.

If the patient is conscious, induce vomiting, but not if the swallowed poison was a strong caustic (strong acid or alkali) or contained petroleum products (gasoline, paint thinner, solvents). To induce vomiting, have the patient drink all the tapwater he/she can hold and put a finger or spoon into the patient's mouth and touch the back of the throat. Collect the vomited material in a suitable container for later analysis. Repeat by filling the stomach with water again and induce vomiting.

Conserve body warmth by wrapping the patient in blankets.

E.17.3 Systemic Poisons

Effective and useful specific antidotes for poisoning are limited in number, and their improper use may complicate the original injury by producing other forms of poisoning. In the first-aid situation, measures for the general and supportive treatment of poisoning are more likely to save lives than ill-considered and heroically-applied antidotes.

In the rare instance in which there is an identifiable high risk of death from acute poisoning by a specific cause (work with organophosphate pesticides at lethal concentrations, for example), a physician's services must be obtained prior to exposure to develop specific first-aid instructions, to obtain necessary emergency drugs and antidotes, to train first-aid personnel, and to plan for transport and definitive care.

Emergency measures include:

- Maintain respiration and circulation.
- Administer oxygen as indicated.
- Observe and treat for shock.
- If the victim is unconscious, place him/her in prone or semi-prone position.
- Collect vomitus/urine, if passed, to aid in later identification of the poison.

E.17.4 Identify Chemical Agent

Knowledge of the offending agent(s) is of utmost help to emergency medical personnel who will have to care for victims. Every attempt should be made to obtain and transmit as much information as possible about the cause, nature, and circumstances of the injury. If the exact chemical cannot be identified, educated guesses as to class of substance, etc., may still be helpful. The following information will also be helpful:

- Physical state of the agent (solid, liquid, gas).
- Odor.
- Trade name.
- Use.
- Presence of any labels.
- Inflammability warning.

ATTACHMENT 6

HEAT AND COLD STRESS PREVENTION AND MONITORING

WESTON

HEAT AND COLD STRESS PREVENTION AND MONITORING

Heat stress usually is a result of protective clothing decreasing natural body ventilation, although it may occur at any time work is being performed at elevated temperatures.

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physical reactions can occur, ranging from mild (such as fatigue, irritability, anxiety, and decreased concentration, dexterity, or movement) to fatal. Because heat stress is one of the most common and potentially serious illnesses at waste sites, regular monitoring and other preventive measures are vital. Site workers must learn to recognize and treat the various forms of heat stress. The best approach is preventive heat stress management. In general:

- Have workers drink 16 ounces of water before beginning work, such as in the morning or after lunch. Provide disposable 4-ounce cups, and water that is maintained at 50-60°F. Urge workers to drink 1 to 2 of these cups of water every 20 minutes for a total of 1 to 2 gallons per day. Provide a cool area for rest breaks. Discourage the intake of coffee during working hours. Monitor for signs of heat stress.

- Acclimate workers to site work conditions by slowly increasing workloads, i.e., do not begin site work activities with extremely demanding activities.

- Provide cooling devices to aid natural body ventilation. These devices, however, add weight and their use should be balanced against worker efficiency. An example of a cooling aid is long cotton underwear which acts as a wick to absorb moisture and protect the skin from direct contact with heat-absorbing protective clothing.

- In extremely hot weather, conduct field activities in the early morning and evening.

- Ensure that adequate shelter is available to protect personnel against heat as well as cold, rain, snow, etc. which can decrease physical efficiency and increase the probability of both heat and cold stress. If possible, set up the command post in the shade.

- In hot weather, rotate shifts of workers wearing impervious clothing.

- Good hygienic standards must be maintained by frequent changes of clothing and showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should immediately consult medical personnel.

F.1 HEAT STROKE

Heat stroke is an acute and dangerous reaction to heat stress caused by a failure of heat regulating mechanisms of the body; the individual's temperature control system that causes sweating stops working correctly. Body temperature rises so high that brain damage and death will result if the person is not cooled quickly.

- Symptoms - Red, hot, dry skin, although person may have been sweating earlier; nausea; dizziness; confusion; extremely high body temperature; rapid respiratory and pulse rate; unconsciousness or coma.

- Treatment - Cool the victim quickly. If the body temperature is not brought down fast, permanent brain damage or death will result. Soak the victim in cool, but not cold water; sponge the body with cool water or pour water on the body to reduce the temperature to a safe level (102°F). Observe the victim and obtain medical help. Do not give coffee, tea, or alcoholic beverages.

F.2 HEAT EXHAUSTION

Heat exhaustion is a state of very definite weakness or exhaustion caused by the loss of fluids from the body. The condition is much less dangerous than heat stroke, but it nonetheless must be treated.

- Symptoms - Pale, clammy, moist skin; profuse perspiration and extreme weakness. Body temperature is normal, pulse is weak and rapid, breathing is shallow. The person may have a headache, may vomit, and may be dizzy.

- Treatment - Remove the person to a cool, air conditioned place, loosen clothing, place in a head-low position and provide bed rest. Consult physician, especially in severe cases. The normal thirst mechanism is not sensitive enough to ensure body fluid replacement. Have patient drink 1 to 2 cups of water immediately, and every 20 minutes thereafter until symptoms subside. Total water consumption should be about 1 to 2 gallons per day.

F.3 HEAT CRAMPS

Heat cramps are caused by perspiration that is not balanced by adequate fluid intake. Heat cramps are often the first sign of a condition that can lead to heat stroke.

- Symptoms - Acute painful spasms of voluntary muscles, e.g., abdomen and extremities.

- Treatment - Remove victim to a cool area and loosen clothing. Have patient drink 1 to 2 cups of water immediately, and every 20 minutes thereafter until symptoms subside. Total water consumption should be 1 to 2 gallons per day.

F.4 HEAT RASH

Heat rash is caused by continuous exposure to heat and humid air and aggravated by chafing clothes. The condition decreases ability to tolerate heat.

- Symptoms - Mild red rash, especially in areas of the body that come into contact with protective gear.

- Treatment - Decrease amount of time in protective gear and provide powder to help absorb moisture and decrease chafing.

F.5 HEAT STRESS MONITORING AND WORK CYCLE MANAGEMENT

For strenuous field activities that are part of ongoing site work activities in hot weather, the following procedures shall be used to monitor the body's physiological response to heat, and to manage the work cycle, even if workers are not wearing impervious clothing. These procedures are to be instituted when the temperature exceeds 70°F.

- Measure heart rate - Heart rate should be measured by the radial pulse for 30 seconds as early as possible in the resting period. The heart rate at the beginning of the rest period should not exceed 110 beats/minute. If the heart rate is higher, the next work period should be shortened by 33 percent, while the length of the rest period stays the same. If the pulse rate still exceeds 110 beat/minute at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent. The procedure is continued until the rate is maintained below 110 beats/minute.

- Measure body temperature - When ambient temperatures are over 90°, body temperatures should be measured with a clinical thermometer as early as possible in the resting period. If the oral temperature exceeds 99.6°F at the beginning of the rest period, the following work cycle should be shortened by 33 percent. The procedure is continued until the body temperature is maintained below 99.5°F.

- Physiological monitoring schedule - The following Suggested Frequency of Physiological Monitoring Schedule for Fit and Acclimated Workers shall be used as a guideline:

Temperature	Level D	Level C
°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
.5°F (30.8°-32.2°C)	After each 60 minutes of work	After each 30 minutes of work
2.5°-87.5°F (28.1°-32.2°C)	After each 90 minutes of work	After each 60 minutes of work
7.5°-82.5°F (25.3°-28.1°C)	After each 120 minutes of work	After each 90 minutes of work
2.5°-77.5°F (22.5°-25.3°C)	After each 150 minutes of work	After each 120 minutes of work

Measure the air temperature with a standard thermometer. Estimate fraction of sunshine by judging what percent the sun is out.

100 percent sunshine = no cloud cover = 1.0
50 percent sunshine = 50 percent cloud cover = 0.5
0 percent sunshine = full cloud cover = 0.0

Adjusted temperature = actual temperature + 13 (percent sunshine factor).

The length of work period is governed by Frequency of Physiological Monitoring. The length of the rest period is governed by physiological parameters (heart rate and oral temperature). For example, if an individual's heart rate exceeds 110 beats/minute at the beginning of the rest period, that individual will remain on rest-time until his/her heart rate drops well below 110 beats/minute and their next work period (= duration of time before suggested physiological monitoring) is decreased by 33 percent.

F.6 COLD STRESS

Persons working outdoors in low temperatures, especially at or below freezing, are subject to cold stress. Exposure to extreme cold for a short time causes severe injury to the surface of the body, or results in profound generalized cooling, causing death. Areas of the body which have high surface area-to-volume ration, such as fingers, toes, and ears, are the most susceptible.

Protective clothing generally does not afford protection against cold stress. In many instances, it increases susceptibility..

Two factors influence the development of a cold injury: ambient temperature and the velocity of the wind. Wind chill is used to describe the chilling effect of moving air in combination with low temperature.

As a general rule, the greatest incremental increase in wind chill occurs when a wind of 5 mph increases to 10 mph. Additionally, water conducts heat 240 times faster than air; thus, the body cools suddenly when chemical-protective equipment is removed if the clothing underneath is perspiration-soaked.

ATTACHMENT 7

SUBCONTRACTORS' HEALTH AND SAFETY AGREEMENTS

WESTON

SUBCONTRACTOR'S HEALTH AND SAFETY AGREEMENT

I, _____, have been given authority by the Board of Directors of _____(hereafter designated as Subcontractor) to agree to and implement the procedures as stated in the Riverbank Army Ammunition Plant (RBAAP) Technical Plan and RBAAP Health and Safety Plan. I certify that:

1. All Subcontractor personnel involved in work activities on and adjacent to the RBAAP site (hereafter referred to as Site):

   A. understand that the work is to be performed on a known hazardous waste site and that protective clothing and respiratory protective devices may be required.

   B. understand and have agreed to the provisions of the Health and Safety Plan.

   C. have been examined by a licensed physician in accordance with 29 CFR 1910. The physician's certification(s) is attached.

   D. have been trained in accordance with the applicable sections of 29 CFR 1910 and 29 CFR 1926/1910.

   E. have agreed to work under the direction of the Contractor's Site Health and Safety Coordinator or Field Safety Officer.

2. All equipment provided to Subcontractor personnel by the Subcontractor is NIOSH/MSHA approved, as appropriate, and in working condition, as specified by the manufacturer.

3. All Subcontractor respiratory and personnel protection programs that apply to this site are in compliance with 29 CFR 1910 and 29 CFR 1926/1910.

4. The Subcontractor maintains a health and safety program in accordance with the applicable sections of 29 CFR 1910.

I agree to comply with the statement I have initialed below (initial only 5 or 6, not both):

5. _____ I agree that all Subcontractor personnel shall comply with the provisions of the Contractor's Health and Safety Plan.

WESTON

RESPIRATOR INSPECTION, CLEANING, MAINTENANCE AND STORAGE

INSPECTION

Respirators will be inspected before and after each use, and those respiratory protective devices not in routine use at the site will be inspected at least weekly. The inspections of the respirators will include the following:

- Examination of the headstraps for:
  - Breaks, loss of elasticity, broken or malfunctioning buckles, and attachments.
- Examination of the facepiece for:
  - Excessive dirt, cracks, tears and holes, distortion, or inflexibility.
- Examination of the exhalation valve for the following after removing its cover:
  - Foreign material, cracks, tears, distortion in the valve material, improper insertion of the valve body in the facepiece, defective valve cover, abnormalities in the valve body, improper installation of the valve in the valve body.
- Examination of the air purifying elements for:
  - Incorrect cartridge or canister for the hazard, abnormalities in the holder, expired shelf life of cartridge or canister, cracks or dents in the cartridge or canister.

The manufacturer's time limits for the use of respirator canisters and filters will be conformed to, and respirator canister filters which have exceeded their period of use will be replaced with new canisters. Canisters will be replaced upon odor breakthrough.

CLEANING

Routinely used respirators will be cleaned and disinfected daily by the employee to help assure proper protection. The FSO will have ultimate responsibility to maintain the respirators and be knowledgeable in the cleaning and disinfecting requirements. Washing with detergent in warm water using a brush, thoroughly rinsing in clear water, and air drying in a clean place is the procedure which will be used for care of the respirators.

MAINTENANCE

If in the cleaning or inspection of the respirators by the users, broken or nonfunctioning parts of the respirator are found, they are to be reported to the FSO. A replacement part or a new respirator will be issued.

STORAGE

The respirators will be stored in an area where they will be protected against mechanical damage. The respirators will also be stored in an area that provides protection against dust, heat, extreme cold, excessive moisture, or damage by chemical contact.

SECTION 9

SCHEDULE OF DELIVERABLES

A milestone chart has been prepared for the activities and deliverables for the RMA Abandoned Well Closure Program Task-IRA-3 (Figure 9-1). This schedule is based on the mobilization of the field crew to RMA on Monday, November 14, 1988.

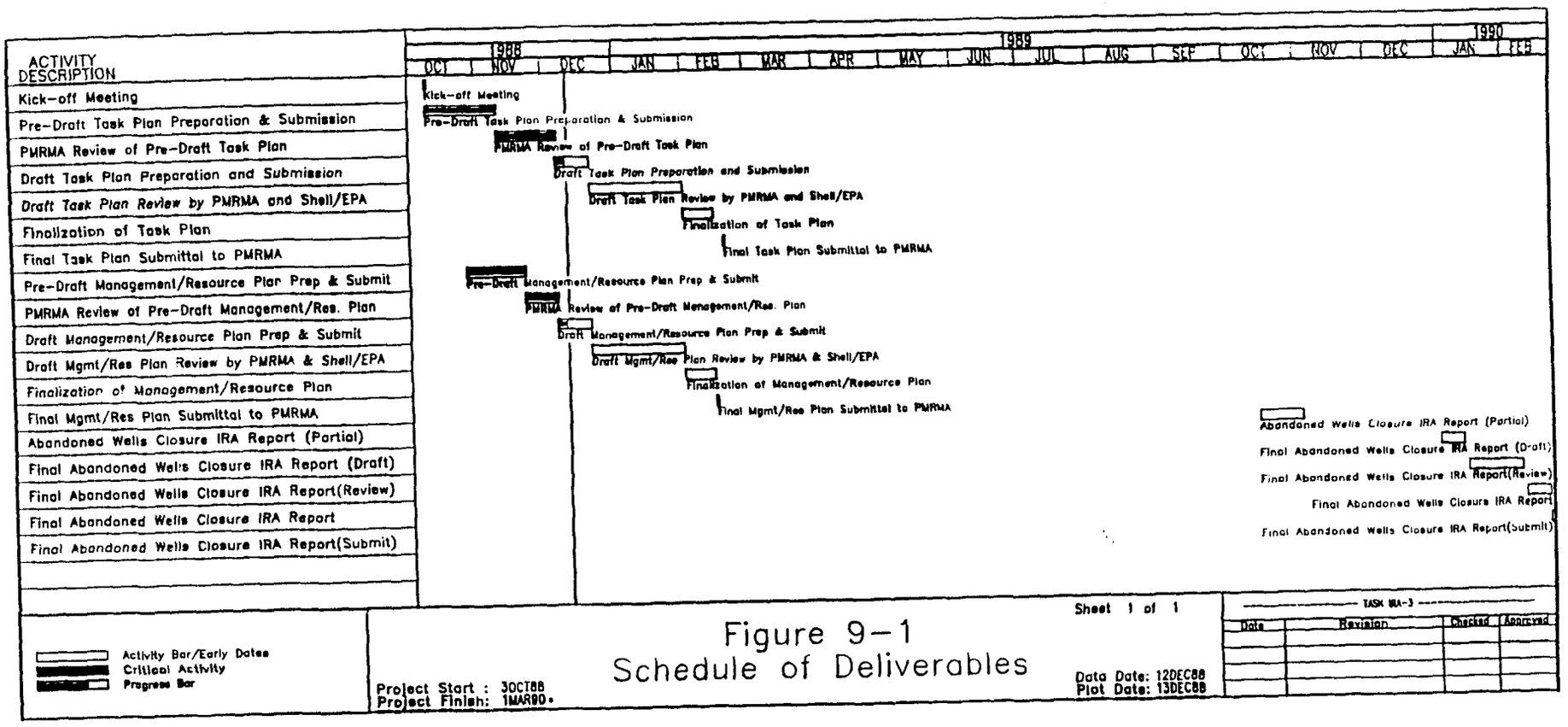

Figure 9-1
Schedule of Deliverables

Figure 9-1 Schedule of Deliverables

SECTION 10

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APPENDIX A

TASK IRA-3 WELL DATABASE

TITLE	UNITS/ DESCRIPTION	FIELD SIZE	ABBREVIATION
WELL DESIGNATION/IDENTIFICATION DATA			
Section number	---	4	SECT
Well number	---	6	WELL #
Bore number		4	BORE
Grid number		5	GRID
WELL INSTALLATION DATA			
Installed by (organization name)	---	10	INSTALL BY
Date installed	MMDDYY	6	INSTAL DATE
Intended purpose	---	10	INSTALL PURPOSE
Comments/remarks	---	20	INSTALL REMARKS
WELL SEARCHES PERFORMED			
First search by (organization name)	---	10	FSEARC BY
First search date	MMDDYY	6	FSEARC DATE
Second search by (organization name)	---	10	SSEARC BY
Second search date	MMDDYY	6	SSEARC DATE
Comments/remarks	---	20	SEARCH REMARKS
WELL LOCATION DATA			
Coordinates:			
- East	feet	6	EAST COORD
- North	feet	6	NORTH COORD
Surface elevation (MSL)	feet	7	SURF ELEV
Inner casing elevation (MSL)	feet	7	TOC
Survey Accuracy	---	2	SA

STRATIGRAPHY DATA

Formation 1:			
Formation name 1	All/Dvr/Arp	3	FMI
Depth to top 1	feet	5	DEPTH TOP 1
Thickness	feet	5	TKNS 1
Primary soil/rock type 1	Sand/Grav/Silt/ Clay/Shal/Slst/Sstn	4	SLRK TYP 1
Comments/remarks 1	---	20	REMARKS 1
Formation 2:			
Formation name 2	All/Dnv/Arp	3	FM 2
Depth to top 2	feet	5	DEPTH TOP 2
Thickness 2	feet	5	TKNS 2
Primary soil/rock type 2	Sand/Grav/Silt/ Clay/Shal/Slst/Sstn	4	SLRK TYP 2
Comments/remarks 2	---	20	REMARKS 2
Formation 3:			
Formation name 3	All/Dnv/Arp	3	FM 3
Depth to top 3	feet	5	DEPTH TOP 3
Thickness 3	feet	5	TKNS 3
Primary soil/rock type 3	Sand/Grav/Silt/ Clay/Shal/Slst/Sstn	4	SLRK TYP 3
Comments/remarks 3	---	20	REMARKS 3
Formation 4:			
Formation name 4	All/Dnv/Arp	3	FM 4
Depth to top 4	feet	5	DEPTH TOP 4
Thickness 4	feet	5	TKNS 4
Primary soil/rock type 4	Sand/Grav/Silt/ Clay/Shal/Slst/Sstn	4	SLRK TYP 4
Comments/remarks 4	---	20	REMARKS 4

CASING DATA

Multiple casings	Y/N	4	MULT CAS
Casing No. 1:			
Material 1	PVC/SS/Stl/Iron Brick	4	MTL 1
Diameter 1	inches	4	DIA 1
Length 1	feet	5	LEN 1
Depth to top 1	feet	5	DEPTH TOP 1
Formation 1	All/Dnv/Arp	3	FM 1
Backfill Material 1	Soil/Bent/Grou	4	BACK MTL 1
Depth to top of backfill 1	feet	5	DEPTH BKF 1
Length of backfill 1	feet	5	LEN BKF 1
Seal Material 1	Ctgs/Bent/Grou	4	SEAL MTL 1
Depth to top of seal 1	feet	5	DEPTH SEAL 1
Seal length 1	feet	5	SEAL LEN 1
Comments/remarks 1	---	20	SEAL LEN 1
Coupling type	Screw/Glue/Weld	5	CPLG TYPE
Casing No. 2:			
Material 2	PVC/SS/Stl/Iron/	4	MTL 2

	Brck		
Diameter 2	inches	4	DIA 2
Length 2	feet	5	LEN 2
Depth to top 2	feet	5	DEPTH TOP 2
Formation 2	All/Dnv/Arp	3	FM 2
Backfill material 2	Soil/Bent/Grou	4	BACK MTL 2
Depth to top of backfill 2	feet	5	DEPTH BKF 2
Length of backfill 2	feet	5	LEN BKF 2
Seal material 2	Ctgs/Bent/Grou	4	SEAL MTL 2
Depth to top of seal 2	feet	5	DEPTH SEAL 2
Seal length 2	feet	5	SEAL LEN 2
Comments/remarks 2	---	20	REMARKS 2
Coupling type	Screw/Glue/Weld	5	CPLG TYPE
Casing No. 3:			
Material 3	PVC/SS/Stl/Iron/ Brck	4	MTL 3
Diameter 3	inches	4	DIA 3
Length 3	feet	5	LEN 3
Depth to top 3	feet	5	DEPTH TOP 3
Formation 3	All/Dnv/Arp	3	FM 3
Backfill materials 3	Soil/Bent/Grou	4	BACK MTL 3
Depth to top of backfill 3	feet	5	DEPTH BKF 3
Length of backfill 3	feet	5	LEN BKF 3
Seal material 3	Ctgs/Bent/Grou	4	SEAL MTL 3
Depth to top of seal 3	feet	5	DEPTH SEAL 3
Seal length 3	feet	5	SEAL LEN 3
Comments/remarks 3	---	20	REMARKS 3
Coupling type	Screw/Glue/Weld	5	CPLG TYPE
WELL SCREEN DATA			
Multiple Screens?	Y/N	4	MULT SCRN
Screen No. 1:			
Aquifer 1	All/Dnv/Arp	3	AQ1
Diameter 1	inches	4	DIA1
Length 1	feet	5	LEN1
Slot/Mesh Size 1	Sieve No.	4	SLT1
Depth to top 1	feet	5	DEPTH TOP 1
Comments/remarks 1	---	20	REMARKS 1
Screen No. 2:			
Aquifer 2	All/Dnv/Arp	3	AQ2
Diameter 2	inches	4	DIA2
Length 2	feet	5	LEN2
Slot/Mesh Size 2	Sieve No.	4	SLT2
Depth to top 2	feet	5	DEPTH TOP 2
Comments/remarks 2	---	20	REMARKS 2
Screen No. 3:			
Aquifer 3	All/Dnv/Arp	3	AQ3
Diameter 3	inches	4	DIA3
Length 3	feet	5	LEN3
Slot/Mesh Size 3	Sieve No.	4	SLT3

Depth to top 3	feet	5	DEPTH TOP 3
Comments/remarks 3	---	20	REMARKS 3

WELL SCREEN PACKING DATA

Packing type 1	Sand/Grav/None	4	PCKG TYP 1
Depth to top 1	feet	5	DEPTH PCKG 1
Length 1	feet	5	PCKG LEN 1
Thickness 1	inches	4	PCKG TKN 1
Development 1	Y/N	4	PCKG DEV 1
Packing type 2	Sand/Grav/None	4	PCKG TYP 2
Depth to top 2	feet	5	DEPTH PCKG 2
Length 2	feet	5	PCKG LEN 2
Thickness 2	inches	4	PCKG TKN 2
Development 2	Y/N	4	PCKG DEV 2
Packing type 3	Sand/Grav/None	4	PCKG TYP 3
Depth to top 3	feet	5	DEPTH PCKG 3
Length 3	feet	5	PCKG LEN 3
Thickness 3	inches	4	PCKG TKN 3
Development 3	Y/N	4	PCKG DEV 3

UNSCREENED/OPEN HOLE DATA

Multiple open hole sections	Y/N	4	MULT OPEN
Aquifer 1	All/Dnv/Arp	3	AQ1
Diameter 1	inches	4	DIA1
Length 1	feet	5	LEN1
Depth to top 1	feet	5	DEPTH TOP 1
Comments/remarks 1	---	20	REMARKS 1
Aquifer 2	All/Dnv/Arp	3	AQ2
Diameter 2	inches	4	DIA2
Length 2	feet	5	LEN2
Depth to top 2	feet	5	DEPTH TOP 2
Comments/remarks 2	---	20	REMARKS 2

SECURITY CASING DATA

Height	feet	4	SEC HT
Diameter	inches	4	SEC DIA
Cap type	Screw/Cap/Lock/ Open	5	SEC CAP
Comments/remarks	---	20	SECURITY CASING REMARKS

WELLHEAD CAP DATA

Cap type	Screw/Cap/Open	5	WELL CAP
Vented?	Y/N	4	WELL VENT
Comments/remarks	---	20	WELL CAP REMARKS

WELL BOTTOM CAP DATA

Material	PVC/SS/Stl/Iron	4	BOOT MTL
Diameter	inches	4	BOOT DIAM
Length	feet	4	BOOT LEN
Depth to top of boot	feet	5	DEPTH BOOT
Comments/remarks	---	20	WELL BOOT REMARKS

SANITARY SEAL DATA

Material	Soil/Grou/Bent/ Conc	4	SEAL MTLS
Outer Diameter	feet	4	SEAL DIAS
Depth	feet	4	SEAL DEPS

ASSUMED WELL PURPOSE

Remedial injection	Y/N	4	PURP INV
Other	Y/N	4	PURP OTH
Unknown	Y/N	4	PURP UNK
Comments/remarks	---	20	PURPOSE REMARKS

PROPOSED WELL CLOSURE ACTIVITIES

Backfill with soil	Y/N	5	PCLOS BF
Extract casing	Y/N	5	PCLOS EXCSG
Perforate casing	Y/N	5	PCLOS PERCS
Install grout	Y/N	5	PCLOS GROUT
None required-already closed	Y/N	5	PCLOS NONEC
None required-leave open	Y/N	5	PCLOS NONE O
Comments/remarks	---	20	PROP CLOSURE REMARKS

CLOSURE ACTIVITIES PERFORMED

Date closure started	MMDDYY	6	CLOS START
Date closure completed	MMDDYY	6	CLOS COMPL
Overdrilled	Y/N	5	CLOS OVER
Excavated	Y/N	5	CLOS EXG
Casing removed/extracted	Y/N	5	CLOS CSEXC
Casing remaining	feet	5	CLOS CSREM
Perforated casing	Y/N	5	CLOS CSPER
Well grouted	Y/N	5	CLOS CSGRO
Well backfilled	Y/N	5	CLOS BF
Closure by (organization name)	---	10	CLOS BY
Comments/remarks	---	20	CLOSURE REMARKS

OBSERVED WELL EQUIPMENT

Pump type	Subm/Turb	5	EQUIP PUMTY
Pump size	inches	5	EQUIP PUMSZ
Bailer type/material	Tefl/PVC/Stl	5	EQUIP BLRTY
Bailer size	inches	5	EQUIP BLRSZ
Hose (from pump)	Y/N	5	EQUIP HOSE
Pipe (from pump)	Y/N	5	EQUIP PIPE
Electric cables	Y/N	5	EQUIP CABLE
Depth of pump	feet	5	EQUIP PUMDP
Junk in well	Y/N	5	EQUIP JUNK
Depth of junk	feet	5	EQUIP DJUNK
Comments/remarks	---	20	EQUIP REMARKS

FINAL WELL STATUS

Monitor well	Y/N	5	FSTAT MW
Water supply well	Y/N	5	FSTAT WS
Remedial extraction well	Y/N	5	FSTAT REMEX
Remedial injection well	Y/N	5	FSTAT REMIN
Other purpose well	Y/N	5	FSTAT OTH
Comments/remarks	---	20	FSTAT REMARKS
Date final status established	MMDDYY	6	FSTAT DATE
Final status documented in (report, log, etc.)	---	10	FSTAT DOC IN

APPENDIX B

EPA REGION VIII PROCEDURE FOR HANDLING OF MATERIALS FROM DRILLING, TRENCH EXCAVATION, AND DECONTAMINATION DURING CERCLA/RI/FS OPERATIONS AT THE ROCKY MOUNTAIN ARSENAL

At the Rocky Mountain Arsenal, extensive CERCLA RI/FS operations are being conducted by the Department of the Army and EPA. There is a relatively large volume of potentially contaminated material which will be disturbed by operations such as drilling, trenching, and decontamination of personnel and equipment. Therefore, EPA believes it is necessary to develop a procedure for handling such materials. The following procedure has been developed with the intent of providing a sufficient level of protection for the environment, while allowing operations to proceed unhindered by administrative requirements. The Army should adopt the following procedure for handling materials from such operations:

1. Use past records and studies to identify possible areas of contaminated soil and/or ground water plumes

2. At sites thought to be uncontaminated:

   Use HNu, OVA, and other devices as appropriate for the possible wastes at the respective site, to screen water, mud, and decontamination materials taking readings at least every five feet.

   Use constant visual and odor inspection to screen such materials.

   If all screening techniques indicate no contamination, dispose of materials in the most practical way (drum on ground, trench, etc.).

   The Army, EPA, or state may take samples of, and chemically analyze, any material to confirm the screening techniques findings.

If any screening technique indicates contamination, drum that material, and all material from there on down the hole or trench.

3. At sites thought possibly contaminated, either on the surface or lower:

   Follow the same procedures described above for sites thought to be uncontaminated.

4. At sites known to be contaminated, either on the surface or lower:

   Evaluate as described above for sites thought to be uncontaminated until near (clearly still above) the site contamination level.

   If evaluation shows contamination, drum as above.

   If evaluation shows no contamination, discard as above.

   Clearly before reaching known contamination level, begin drumming all material, despite screening technique results.

5. All drummed material:

   Must be removed to a site meeting RCRA Part 265 design standards within three months of drumming, unless tested non-hazardous before that time.

   May be stored at such site until EPA approval of its interim on-site treatment, disposal, or a final CERCLA remedy.

   The storage site must comply with pertinent substantive RCRA requirements, but need not be permitted.

6. Testing procedures:

   Any drummed material may be deemed hazardous without testing, but each drum must be identified (properly labeled) as the RCRA waste(s) from the respective drill site known from past studies, drilling tests, and/or screening results. However, later testing may be required by a RCRA landfill for acceptance or disposal.

   Each drum not thus deemed-hazardous-without-testing must be tested within six weeks of drumming. And, if drums are to be tested,

   A drum sampling procedure(s) shall be proposed for approval by EPA. The procedure(s) shall provide for obtaining a representative sample(s) from each drum or set of drums containing similar material.

   A testing methodology(ies) shall be proposed, for approval by EPA; the methodology(ies) may vary by sample.

Alternately, testing performed on core samples collected at various depths may be used in categorizing the drummed material, if approved by EPA.

A list of wastes for which each sample is to be tested shall be proposed, for approval by EPA. Each list shall consist of at least indicator parameters for the suspected RCRA waste(s) from the originating drill site; such parameters shall be chosen based on their prevalence, mobility, ease of detection, etc.

7. Determination of fate:

Each test result shall be compared with any established RCRA level and with NPDES standards for each waste found present, unless EPA has agreed to a different level for that waste -- which then use.

Each waste thus tested nonhazardous may be discarded in the most practical manner.

Each waste thus deemed or tested hazardous must be managed substantively as a RCRA waste, until EPA approved of its interim on-site treatment, disposal, or a final CERCLA remedy.

APPENDIX C
RESPONSES TO U.S. EPA COMMENTS ON THE DRAFT TASK PLAN FOR RMA ABANDONED WELL CLOSURE PROGRAM

Comment 1: Page 2-17, Table 2-3. The table indicates that a first level field search was performed for 188 wells. However, the Task 37 Draft Final Report on the abandoned well program (Ebasco, September 1988) indicateds that a first level field search was performed for 189 wells. This discrepancy should be corrected in the table.

Response 1: *Because the well list provided in Table 2-2 has been updated to include all the wells under consideration for closure. Table 2-3 and associated text has become redundant and has been removed from the Task Plan.*

Comment 2. Page 2-21, first paragraph. When a magnetic anomaly is detected, but no casing is located when excavated, the source(s) of the anomaly should be noted.

Response 1: *Section 2.2.2.2 has been modified to include a notation of the apparant source(s) of magnetic anomalies.*

Comment 3: Page 2-23, water sampling criteria. The four sampling criteria listed are comprehensive and address EPA's prior concerns witht the proposed sampling program. The only wells for which it is known that the sampling interval is completely isolated should be sampled.

Response 3: *Agree*

Comment 4: Pages 6-5 and 6-6, monitor well sampling. It is not clear why the standard well evacuation procedure is to be modified to lower the probability of cross-aquifer contamination since onlywells with definitevely known construction details are to be sampled (see Criteria 1, page 2-23). There is no reason to employ a modified technique if only wells of known construction employ a modified technique if only wells of known construction are sampled, thus standard evacuation procedures should be employed so that the resulting data are of litigation quality. EPA stresses again that it would be best not to sample wells whose integrity of construction is unknown or suspect. EPA feels that modifications to the standard evacuation technique may not preclude induction of cross-contamination.

Response 4: *Modification to the well evacuation procedure has been eliminated and the standard technique will be utilized.*

RESPONSES TO STATE OF COLORADO COMMENTS ON THE DRAFT TASK PLAN FOR RMA ABANDONED WELL CLOSURE PROGRAM DECEMBER 1988

Comment 1: The State agreed to limit the Task 37 study area to those onsite regions either within, adjacent to, or downgradient of contaminant plumes. In effect, this excluded the eastern tier and southern tier from the Task 37 study area. This agreement, however, was limited to Task 37. The Army assured the State that all areas not included in the Task 37 study area would be included in the next phase of this interim action. This understanding is not reflected in this draft task plan. Therefore, the work area must be expanded to include the entire Arsenal. To eliminate the potential for further vertical migration of contamination through wells no longer in use, all abandoned wells located on the Arsenal must be located and properly closed.

Response 1: *Agree - All wells which are currently being considered for closure throughout RMA are reflected in the updated closure list provided in Section 2.1.2 (Table 2-2).*

Comment 2: The plan indicates that if existing monitoring wells in the Denver and/or Arapahoe Formations can be used effectively for monitoring purposes, then water quality samples will not be taken prior to closing abandoned wells in these areas. The State is not aware of any Arapahoe Formation monitoring wells existing at RMA.

Shell Oil Company has requested that the following wells be sampled prior to closure:

Section 02	02A05	SW NW Sec 02
Section 03	03A07	NW NW Sec 03
	03A08	NW SW Sec 03
Section 23	23A06	NE NE Sec 23
Section 24	24A01	SE SE Sec 24
	24A02	NE SE Sec 24
	24A06	NW SW Sec 24
Section 25	25A01	NE NW Sec 25
Section 27	27A06	SW NW Sec 27

Section 33	33A07	SW NW Sec 33
	33A09	NW NW Sec 33
Section 35	35A01	SW NW Sec 35
	35A03	NE NE Sec 35

Advanced notice must be provided to the MOA parties prior to sampling and/or closing the above listed wells. The State may wish to take split-samples from wells which are sampled under this program.

Response 2: *It was agreed at the July meeting of the Steering and Policy Committee that data collected from Pre-1942 would be of little values and therefore, sampling of Pre-1942 wells will not be conducted. No post-1942 wells completed in the Arapahoe Formation are known to exist.*

Comment 3: The State maintains that for all wells which will be sampled, water quality samples should be analyzed for all Task 44 target analytes.

Response 3: *At the Task 37 meeting of the PAS held on June 9, 1987, and attended by Chris Sutton of the Colorado Department of Health and Trish Bohm of the Colorado Attorney General's Office, it was agreed that all water samples obtained under Task 37 will be analyzed for the same constituents on a qualitative level. Since Task IRA-3 is the second phase of the abandoned well program, of which Task 37 was the first phase, the same analytical requirements are expected to apply. These analytes/analyses are volatile halogenated organics/EPA 601, organochlorine pesticides/EPA 608, and phospanates/EPA 625 or USATHAMA 4S. The uncertainty associated with the provenance of the water samples obtained from abandoned wells limits the interpretation of the resulting data to a qualitative level. Because of this constraint, it was deemed prudent to avoid analyzing for the entire Task 4/44 suite of analytes in an attempt to maintain a distinction between the abandoned well program and Task 4/44 data sets, and to more effectively utilize abandoned well program funds for closing wells rather than for collecting sample data of questionable integrity.*

Comment 4: Task 37 reported that 15 pre-1942 wells were not found. Many of these wells had reported depths which extended into the Arapahoe Formation. While it may not be prudent to continue to search for these 15 wells at this time, it should not be assumed that the wells do not exist. If and when new information becomes available, it may be possible to locate these wells.

Response 4: *The final report of this project will include a listing of all wells not found.*